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ABSTRACT

This is the sixth in a series of publications prepared by the U.S. Office of Education which are concerned with an analysis of research in mathematics education. This publication presents a summary analysis of research in mathematics education and includes reports of Cooperative Research Projects supported by the Cooperative Research Program of the U.S. Office of Education for the years 1961 and 1962. Reports of research were received from eighty-three colleges and one hundred and seventy-four reports were selected for inclusion in this publication. The reports deal with elementary school, high school, and college mathematics and include doctoral dissertations, master's theses, and nondegree studies. (FL)

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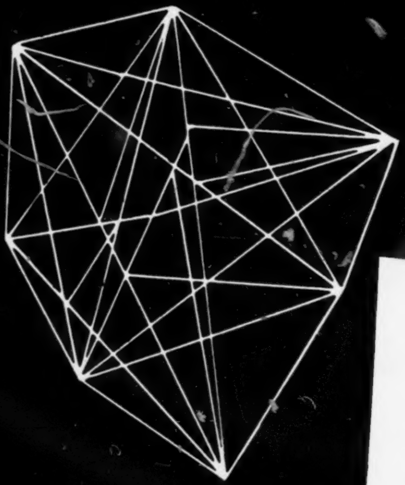
Analysis of RESEARCH IN THE TEACHING OF MATHEMATICS



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ANALYSIS OF RESEARCH IN THE TEACHING OF MATHEMATICS

by

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and

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FOREWORD

This is the sixth in a series of publications that began in 1952 when the U.S. Office of Education, in cooperation with the National Council of Teachers of Mathematics, prepared a summary of research in mathematics education, Circular No. 377. This summary was followed in 1954 by another, Circular No. 377–II. Favorable comments encouraged the inclusion of an analysis with the summary for 1955–56, a feature that was retained in the two biennial reports that followed. This present publication continues the series of cooperative efforts by presenting a summary analysis of research in mathematics education for the calendar years 1961 and 1962. In addition, this publication includes reports of Cooperative Research Projects in mathematics that have been completed.

Appreciation is expressed to the deans of graduate schools, to researchers, and to others who supplied the reports on which the study is based. The Office of Education is grateful to the National Council of Teachers of Mathematics for its assistance in the study.

J. RICHARD SUCHMAN, *Director,*
Curriculum and Demonstration Branch.

PREFACE

To obtain the information for the major part of this study, the U.S. Office of Education, with the assistance of the National Council of Teachers of Mathematics, sent a questionnaire to 1,049 colleges; this number represented colleges that offered graduate work in mathematics education and those whose staffs or students had made contributions to previous studies in this series.

Reports of research were received from 83 colleges. Of the 215 studies reported, 174 were selected for inclusion in the listing in this publication. Doctoral dissertations constituted 111 of the 174 studies; master's theses, 41; and nondegree studies, 22. The investigations dealing primarily with elementary school mathematics numbered 48; with high school mathematics 81; and with college mathematics 45.

The information on the studies funded by the Cooperative Research Program was obtained from within the Office of Education. Descriptions were prepared from the final reports submitted for each project. Persons interested in studying the final reports may obtain copies from two sources: (1) libraries which subscribe to the Library of Congress Documents Expediting Project (including many State university libraries), or (2) the Library of Congress Photoduplication Service, Washington, D.C., which has microfilm copies of all final reports available for about $2.25 per copy (requests for microfilm copies should identify the Cooperative Research Project by project number, title, and author).

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Section I. ANALYSIS

Elementary School

The new elementary mathematics programs present many topics and terms that traditionally have been reserved for more advanced students. It is natural for teachers to question the ability of young pupils to understand these concepts and terms, and the research has reflected their concern. The studies seem to indicate, however, that many young children can learn more mathematics than has been expected of them, but because of differing abilities and differing backgrounds, not all of them can learn the same things at the same age. It may be desirable for some pupils to explore nondecimal systems of numeration in order to understand the decimal system better, but others may know so little about the decimal system to begin with that such a procedure would only leave them in confusion. Thus the crucial question seems to be, what mathematics should what children learn at what age? And on this question, very little research is available.

Aids in effective learning were also a subject of inquiry and, similarly, the crucial question was, which aids for which children and for which topics? If children differ and if they learn differently, some techniques must be more effective with one child than others. Indeed most of the aids that were advocated did seem to help some pupils. Multisensory aids, for example, have been shown to be helpful to some pupils, but research has given little direction as to *which* students and with *which* concepts any given multisensory aid should be used.

Similarly, grouping seems to increase learning of certain topics with some pupils, but the question—when and how can grouping be helpful?—remains unanswered.

The several research studies on the best method of teaching a particular skill or concept belong to a type of research that has not yielded great returns. Perhaps there is no one best method for all pupils to estimate quotients or to learn fractions. There may be a very effective method for teaching certain pupils, but until research discloses more information on which ones, successful teachers will no doubt continue to use many methods in attempting to clarify a mathematical concept.

The highlights of the research done in 1961 and 1962 are given in the following series of questions and answers.

To what extent can mathematics concepts be developed in the elementary grades?

The research seems to indicate that young children can learn considerably more mathematics than the present programs include (19).* In one study emphasizing structural concepts, the experimental group achieved significantly higher than the grade placement norms for the post test (114). Another investigator found second-grade children ready for third-grade work in arithmetic (105).

A study of the SMSG (School Mathematics Study Group) text for grade four showed no significant difference in mastery of traditional work by a group using the SMSG material and another group using a traditional text. However, the learning of sets and geometry by the SMSG group was not reflected in their performance on the test (86).

Some of the new mathematics principles and processes were introduced into a traditional sixth-grade program in which the pupils became more interested in mathematics and exhibited an increase in skill in traditional mathematics (155).

A programed text for a 2-week unit in equations and inequalities in terms of sets and sentences was developed and field tested for use at the fifth- or sixth-grade level. The technique was recommended for schools lacking other means of providing instruction for the mathematically talented (82).

Do manipulative materials increase achievement?

The "bundles" method and the "hundred boards" method of teaching place value to first-grade children seemed to supplement each other (162). A commercially produced, expensive set of number aids was found to be no more effective than inexpensive materials selected by the teacher (66). Use of a variable-base abacus for counting in numeration systems other than base 10 produced no significant gains over the use of the chalkboard alone (79).

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* The numbers in parentheses throughout sec. I denote the number of the study as listed in sec. II.

Counting devices, pictures, games, and supplementary materials have shown a decided increase in use in the last two decades, particularly in the primary grades (154).

Does grouping for instruction increase achievement?

This question continues to intrigue investigators, and the evidence remains inconclusive. In one study randomly grouped pupils made significantly greater gains in computation and reasoning than pupils who were specially grouped within grade levels (32). In a nongraded school, teacher-prepared materials for pupil self-instruction gave promise for use with achievement grouping (178). Subgrouping within a classroom with emphasis upon meaningful instruction, produced significant gains (34, 77, 159). One study indicated that removal of the top group might be beneficial for the less able students (106). Junior high school pupils believe that the top and low groups of students benefit most from ability grouping (72).

Does pupil attitude affect achievement?

One investigator found a higher correlation between pupil attitude and achievement for arithmetic than for spelling, reading, or language (46). A student's general ability to learn seems to be associated with his liking for arithmetic (135, 147). Teacher observation appears inadequate as a method of appraising student attitudes toward mathematics (13).

A case study indicated that underachievement did not become apparent until the fourth grade. Subjects tended to be from home environments that provided little intellectual stimulation, and were characteristically withdrawn and defeatist in their attitudes toward school (128).

Socioeconomic environment was found to have a positive relationship to achievement (28).

Is there a most effective method of teaching fractions?

There are probably too many variables in instructional situations to find one most effective method. In teaching multiplication of fractions, the use of a flannel board with felt discs and automated devices produced significant achievement (107). A comparison of the "mechanical" with the "meaningful" method in the division of fractions produced no significant difference in achievement (143) but the meaningful method produced greater retention (88). The teaching of computation with decimal fractions prior to any formal computation with common fractions, when based on an orderly extension of place value, produced significant gains over the usual procedure (44). During the past decade greater emphasis has been placed on deriving and proving the rules used in performing operations with fractions (151).

Which method of estimating the quotient is best?

The research seems to indicate that there is no one best method. A computational analysis of the division of 44,550 dividends by 81 two-digit divisors (nonmultiples of 10) disclosed that the "round-off" method gave the true quotient on the first estimate a greater percent of the time than either the "apparent" or the "increase-by-one" method. In a study with fifth-grade children, however, the three methods were equally effective in improving children's abilities to estimate quotients (68).

In division by one- and two-place decimals, children preferred to use the caret sign to show that the divisor and dividend were multiplied by a power of 10 (78).

How can problem-solving abilities be improved?

Vocabulary exercises, talking through problem situations, diagramming the problem, estimating the answer, and writing solutions produced a slight gain in favor of the experimental group (45). Both above- and below-average problem solvers benefited from 30 problem-solving lessons, each written at two levels of difficulty and each followed by an optional difficult problem titled "How's your P.Q.?" (127). Changes in patterns of thinking produced by use of a specific textbook series were not accompanied by a significant difference in measured problem-solving competence (97).

Does increased time increase achievement?

Pupils studying arithmetic 55 to 60 minutes daily made significantly greater gains both in arithmetic reasoning and in computation than did those studying the subject 35 to 45 minutes daily. These findings, which were for the group as a whole, were also confirmed by the findings, respectively, for the subgroup with IQ's of 95 or below and the one with IQ's of 115 or above (80).

How effective is classroom teacher followup to televised instruction?

More research is needed on this question. One investigator sought to measure the value of an introduction and followup to televised arithmetic instruction. One class merely viewed the program. Another class, which received help from the teacher before and after the viewing, made greater gains during the first half of the experiment, but did not achieve significantly higher during the second half (171).

Junior and Senior High School

Many of the studies on high school mathematics are directly related to the so-called new mathematics. Considerable interest was shown in evaluating the School Mathematics Study Group material. Most of these evaluations compared, by means of traditional tests, the achievement of pupils who studied the SMSG material with that of pupils who studied traditional material, and most of them showed that the pupils studying the SMSG material did learn traditional material. There is evidence that these pupils learned additional material, too, that the others had no opportunity to learn. Little information has emerged on the effect of the new programs in developing a pupil's ability as either a scientist or nonscientist.

High school pupils have been shown to be capable of learning many concepts traditionally reserved for college students. Many mathematicians enthusiastically recommend inclusion of the "new" topics in the high school program, although some strongly discount their value in high school. Their value is in fact undocumented, and at present decisions on the introduction of these programs are based generally only on opinions of educators and mathematicians.

The high school studies reported indicate that the chronological age of the pupil is not the prime factor in determining his ability to understand mathematical concepts. In one study, 10 percent of the fifth-grade pupils were able to master certain mathematical concepts more thoroughly than 10 percent of the pupils in the ninth grade. Many studies indicate that certain eighth-grade pupils can succeed better in elementary algebra than many ninth-grade pupils, but few studies shed light on the desirability of eighth-grade pupils learning the subject.

Many mathematicians and teachers contend that a knowledge of sets and set terminology expedites learning of other topics, but the reported research fails to prove or disprove this contention. One study reported, however, that a knowledge of sets was of no value in developing the rational number system.

Research workers were active in studying the effects of programed instruction on the learning of mathematics. Students do learn through programed instruction, but whether they learn better than through other methods of instruction is not known. In fact, many researchers are more interested in establishing the particular things that might best be done through programed instruction—for example, drill in multiplication—or in discovering the characteristics of those students who seem to profit most from programed instruction. The important ways in which programed instruction can be combined with conventional instruction have not been greatly explored, although its use in connection with TV instruction is being investigated.

Findings on these and other topics are discussed in the following series of questions and answers.

What do evaluations of the "new" mathematics programs show?

Research seems to indicate that high school students using a modern program do as well in standardized tests as students using traditional material. In addition, the students of a modern program learn concepts not treated on the usual standardized test.

One investigator found that 92 classes of students using SMSG materials in grade 7–12 did as well as students from all parts of the Nation have done on standard tests (87). Another investigator found that students who were taught with traditional texts performed as well on standardized achievement tests as those who used SMSG texts (171). A third investigator obtained a similar finding (140).

In a comparison of achievement by a ninth-grade group using the UICSM (University of Illinois Committee on School Mathematics) text with that by another ninth-grade group using a traditional text, students who were in the uppermost third on the basis of intelligence made a significantly greater gain in understanding basic mathematical concepts (99).

In a comparison of algebra textbooks, no radical differences in content were found in the Ball State Teachers College program

(Muncie, Ind.) SMSG, or UICSM texts, despite the differences in their methods of attacking principal ideas (129, 144). A frequently voiced criticism of the new programs is that they lack adequate drill exercises, but one investigator found supplemental drill to the SMSG course neither more nor less effective than no drill in increasing achievement (81).

Five criteria were established for the selection of topics for a modern mathematics curriculum, and an analysis was made showing how they might be used in appraising a curriculum (59).

A comparison of the effectiveness of teaching a deductive number-systems course through algebra as against teaching it through geometry produced a difference in favor of the former, although not a statistically significant one (11).

Do the SMSG 7R and 9R (regular) texts produce greater achievement gains than the 7M and 9M (for the student whose mathematical talent is underdeveloped) texts? One study found that, for each teacher, the average score on the SMSG unit tests was higher for students using the M text than for those using the regular text. Average scores on STEP tests showed no consistent difference (49). Teachers generally preferred the M text over the regular. Another study (113) indicated that the M texts tended to facilitate the learning of mathematics for high-ability students except the very highest achievers.

One investigator found a reordering of topics necessary for a rigorous treatment of the limit concept in the SMSG textbooks (71).

How can the "new" mathematics be used to supplement traditional programs?

To ease the introduction of completely new mathematics programs, some investigators suggest a gradual transition. One investigator developed transition units on numeration systems, elementary set theory, geometry, and properties of numbers for use in grade 8 (117). Another prepared materials for use with average or above-average students in the seventh or eighth grade (164).

Spending 15 minutes twice weekly for 6 weeks on each of three of the newer topics was found to produce a significant difference in achievement gains (153).

An introduction to set theory was prepared primarily for secondary school teachers not well versed in formal set theory (25). A unit on prime numbers and their uses as concept builders was developed to assist teachers who lacked background knowledge (120).

To bridge the gap between traditional high school mathematics and college mathematics, a one-semester course in modern mathematics was developed for the 12th grade (60).

Use of the discovery method (22) and the deliberate nurture of creativity (92) were recommended as means of sustaining student interest in mathematics.

What do the factorial studies of mathematics achievement reveal?

In a study in which fifth-, seventh-, and ninth-grade students were taught the same mathematical concepts and were tested in the same manner, the highest 10 percent of the fifth-graders scored higher than the lowest 10 percent of the ninth-graders; the highest 30 percent of the fifth-graders scored higher than the lowest 30 percent of the seventh-graders; and likewise the highest 30 percent of the seventh-graders scored higher than the lowest 30 percent of the ninth-graders (48).

One year's difference in age apparently makes little difference in achievement in beginning algebra. One investigator found that eighth-grade students achieved significantly higher scores than ninth-grade students (93).

One group of eighth-grade students who had been taught sets, partitions, variables, definitions, postulates, operations, relations, and a postulational development of the rational number system did not perform significantly higher on a test of nonpositive rational numbers than another group of eighth-grade students, who had been taught taxation, insurance, banking, interest, and the metric system prior to the traditional development of the rational number system (73).

Teaching seventh-grade mathematics by the algebraic equation approach produced no significant difference in mathematics achievement (58).

Televised lessons on enrichment topics did not produce significantly greater achievement than face-to-face instruction provided by the same instructor (16).

A 10-day introductory unit in model construction in solid geometry did not increase the achievement gain significantly (122).

A Nebraska study indicated a significant relation between teachers' backgrounds in mathematics and pupil achievement in algebra (53, 96).

Doubling the length of the class period to 110 minutes, but having the class meet on alternate days, made no significant difference in achievement gain. A significant difference did favor the 110-minute class, however, when a variety of classroom and laboratory activities were used (65). Increasing the number of class periods weekly from four to five (thereby increasing the total time) resulted in greater achievement (177).

Is programed instruction effective?

The research seems to show that pupils do learn through programed instruction; however, research does not show that programed instruction is better per se than conventional instruction.

A review of the history, theory, implementation, and possible outcomes of programed learning led one researcher to conclude that the method may best be used as a research tool by the classroom teacher (138).

A comparison of the amount of learning produced by linear and branch methods showed no significant difference (123). In another study the verbal deductive technique was found superior to other combinations of deductive, inductive, verbal, and nonverbal modes (14).

Eighth-grade students achieved an understanding of the elementary aspects of the convergence and divergence of infinite series through programed learning (33). When programed materials in a teaching machine were used as a supplement to usual class instruction in elementary algebra, the better student made more use of the programed material, and the more able the student, the greater the achievement gain (54).

A programed supplement permitted more material to be covered in less time (124). A study of programed learning in first-year algebra showed no appreciable gain over traditional methods, although the high-ability students proceeded more rapidly, completed more materials, and achieved a higher level of mastery. There was some ground for believing that the method was disadvantageous for the slow learner (109). A study of retention of factual knowledge learned by programed instruction revealed no significant difference from that achieved by the usual methods (131).

What are the best predictors of success in mathematics?

One school system found the eighth-grade mathematics grade mark to be the best single predictor of success in first-year algebra (9). In another study the algebra I grade marks gave the highest correlation with algebra II grade marks and with the smallest standard error of estimate (148). The algebra I grade mark also gave the highest correlation coefficient based upon one variable for success in plane geometry. Statistically, a significantly greater correlation coefficient was obtained through use of the verbal IQ score and the algebra I grade mark (57).

Teachers' ranking of pupils' mathematical competencies showed a significant relationship with the achievement of academically talented students in an accelerated mathematics program (94).

Scores on a surprise test to determine the accuracy with which junior high school students could define 30 mathematical terms did not correlate with end-of-course marks (42).

Can junior high school pupils learn elementary probability?

No research was reported on the effectiveness of a junior high school course on probability. One investigator found that students of average and superior ability possess a foundation of knowledge on which instruction in probability could be based (95).

What modifications should be made in the geometry program?

Little research was reported on new geometry programs. One investigator developed a plan for incorporating some of the recent recommendations into a traditional geometry course (35). Another found no significant difference in achievement between a modified geometry program and one of the traditional programs (23).

To conserve time and to gain advantages of learning plane and solid geometry in the same course, suggestions were made that could be adapted to most geometry textbooks (70).

Is the vector method effective for teaching analytic geometry?

Recently, there have been many articles suggesting the vector approach for teaching high school plane geometry and analytic geometry in high school, although research on the desirability of this approach is meager. One study reports that selected problems in solid analytic geometry might be treated more easily by means of vectors whereas others lend themselves to a nonvector treatment. On the one hand, it may be that the most effective method is the use of the vector approach with some topics and not with others. On the other hand, the vector approach may be effective with some students but not with others (133).

What provisions should be made for students with superior ability?

Fifteen lessons on units not usually treated in a geometry course were prepared as enrichment materials. Superior students in heterogeneously grouped classes were excused from class one day a week to use the units, which proved sufficiently interesting to motivate students to independent study (165).

Correspondence courses for the 9th- and 10th-grade SMSG program were made available to high-ability students in Iowa, Wisconsin, Minnesota, and the Dakotas. Percentage of completions would probably have been increased if students taking these courses had been accorded regular academic credit and school-scheduled time (64).

High schools in Lincoln, Nebr., revised programs to enable students superior in mathematics to take elementary algebra in grade 8, intermediate algebra in grade 9, and plane geometry in grade 10. College-credit courses in trigonometry and college-level algebra were offered in grade 11 and analytic geometry in grade 12. About 65 percent of students who took advanced credit examinations became eligible to receive university credit (158).

What topics are suggested for ninth-grade general mathematics?

To generate interest and motivate computation, a unit on numeration systems was developed for use at the beginning of the course (29). Lessons on elementary statistical concepts and coordinate geometry were used with a slow-learning group to make mathematics more meaningful (89).

Another study developed a student workbook and teacher's guide with content on patterns, numeration systems, sets, factors, and primes to be used as preparation for elementary algebra (115). Particular attention to selected elements from the history of mathematics was suggested as a way of developing understanding and increased interest by the students (51). One study pointed out the dearth of research on the slow-learning child (89).

Does study of calculus in high school affect achievement in college calculus?

In a study at a State university in which adjustment was made for scholastic ability and general mathematical background, no significant difference in achievement in the university calculus course was found between a group that had taken high school calculus and another that had not (157).

College

Interest in college mathematics was less widespread among the researchers than in secondary mathematics. Eight studies were primarily concerned with curriculum content. One of these studies recognized the importance of computer technology by developing a course on digital computers for engineering students. Another developed a course in mathematics for industrial management students in a technical school, and a third sought to develop a process for selecting content for a modern course in freshman mathematics. A fused course in mathematics and physics claimed the attention of two researchers. A lack of qualified instructors was preventing a number of small colleges from offering advanced mathematics courses; as a solution, one researcher recommended the offering of a special mathematics course for the nonmathematics, nonscience major in liberal arts colleges that require all students to take mathematics.

Teacher education continued to attract the major interest of research students. Four studies were concerned with the mathematical understandings possessed by elementary education majors. Many prospective teachers of elementary school mathematics do not have the understanding of basic mathematical concepts that experts agree they should have. Operations with fractions seem to present the most difficulty. Surveys of teacher attitudes confirmed previous findings that those teachers who understood basic concepts were more likely to be favorably inclined toward mathematics.

Three followup studies of the National Science Foundation institutes revealed that participation generally resulted in updated content and enriched offerings in the secondary school courses taught by the participants, but that administrative policies were likely to discourage the introduction of courses in modern mathematics. The great need for inservice education was confirmed by one survey that revealed that the work of only one of the four most influential national groups affecting secondary mathematics teaching was known by as many as one-half of all respondents. Need to update curriculum content was reflected by another study that indicated those currently being prepared to teach mathematics will be unfamiliar with the types of secondary school mathematics programs in which they may begin their teaching careers. Twenty of the 48 studies had some aspect of teacher education as their primary concern.

Experiments with television and programed materials indicated that achievement comparable to that attained through traditional teaching methods could be expected; the particular medium appeared not to be a controlling factor. The use of these techniques to facilitate inservice education of teachers appeared to have promise, but little light was shed on how they can be used, either individually or in combination, to serve best the educational needs.

The search for criteria to predict success in further study of mathematics continued to intrigue investigators. No new clues were uncovered in the three studies reported. While teacher marks may not be accurate measures of subject matter achievement, grades earned in high school mathematics were better indicators of success in college courses than IQ scores or scores from a mathematics placement test. The search might become more fruitful if the construct of mathematical ability could be more clearly defined.

Issues considered in the research are discussed in the following series of questions and answers.

What are the mathematical competencies of elementary school teachers of mathematics?

Female teacher-education students in a Southern liberal arts college were found to be mathematically less competent than the noneducation majors in the junior and senior classes. Although not generally different from other students in college admission requirements, the teacher-education students ranked lower in the college-related variables of mathematical competence (142).

A survey of a group of elementary school teachers in Tennessee revealed that 23 percent had had no college mathematics. There was no significant relationship between the extent of college training in mathematics and attitudes toward modern mathematics. As the amount of education increased, however, the number with a favorable attitude increased (101).

Another study revealed that teachers who have had college mathematics have a better grasp of basic mathematical concepts than those who have not had college mathematics. Teachers who have a high degree of understanding of the basic concepts have a favorable attitude toward mathematics (21).

A study of selected arithmetic understandings of undergraduate students in education showed that operations with fractions represent one of the concepts least understood (21, 24, 111).

An examination of mathematics textbooks used in courses for elementary school teachers showed an emphasis on topics from arithmetic, number theory, and approximate computation. Some texts included topics from algebra, statistics, elementary logic, and informal geometry (139). The same study revealed that of the eight items selected from arithmetic, number theory, statistics, elementary logic, and informal geometry, no teacher knew as many as four.

The education of elementary school teachers was so lacking in mathematics according to one study that the investigator recommended making 2 years of high school mathematics a college entrance requirement for prospective elementary teachers (100).

What is the proper preparation of secondary school teachers of mathematics?

In a North Carolina survey of the preparation of secondary school mathematics teachers, the typical respondent had not attended a summer session since 1950. The work of only one of the four most influential national groups affecting secondary mathematics teaching was known by as many as one-half of all respondents (163). Many of those currently prepared to teach mathematics are unfamiliar with the program in which they may begin their teaching careers (50).

More than half the responding participants in an NSF summer institute held a master's degree and more than 40 percent had taken 30 or more semester hours of college mathematics. Participants rated the topic of trends and developments in secondary mathematics as most valuable (168). A poll of the directors of the 1961 NSF Summer Institutes on content for a fifth-year course for mathematics teachers indicated general agreement on topics from algebra, probability, and statistics, but a lack of agreement on content for geometry (179). Generally, participants in NSF institutes introduced new topics and integrated them into the traditional mathematics courses (30). There were strong indications that administrative policies were primary deterrents to additional curriculum change (170).

A large percentage of a group of experienced teachers and undergraduate trainees were unsure of the meaning of the terms "sufficient conditions" and "necessary conditions" when used to reach a logical conclusion (20).

A test was developed to measure a teacher's skill in solving teacher-pupil discussion problems in secondary school mathematics (85).

A comparison between pupil achievement when units of mathematics were taught by student interns and when taught by inservice teachers showed no significant difference (37).

Is televised instruction effective?

Comparable lectures, whether delivered by television or in person seemed to produce comparable learning. The fact that during the followup period a different instructor presented approaches to the mathematical topic different from those presented in the television lecture did not significantly alter the achievement initially obtained (8). In another study, three variations of followup procedures produced no significant differences in achievement (174). Two other studies indicated that televised instruction was not more effective than the traditional method of instruction (75, 176).

How effective is programed instruction in teaching mathematics?

Conventional classroom instruction in elementary statistics was no more effective than programed instruction covering the same topic. The average time needed by the programed instruction group was only 66 percent as great as the average time needed by the conventional instruction group (146). Programed instruction in a college algebra course was found to be more effective than the conventional treatment (69). Experimentation with nonwordal programing gave hope for teaching mathematics to students from varied population groups (145).

As a supplement to televised instruction, programed instruction was more effective than kinescope viewings of solutions of homework problems or a teacher-help session (90).

How can success in college mathematics be predicted?

One study found the number and type of high school mathematics course units and the grade-marks earned more valuable than IQ scores or mathematics placement-test scores for predicting success in college mathematics. College marks were usually one letter grade lower than those earned in high school mathematics (12). Another study found that high school mathematics grades gave a good indication of the quality of work to be expected in the required college mathematics courses (52).

What uses do mathematical models have in the social sciences?

They can be used to predict future events, to describe desirable behavior, to organize large masses of data, and to indicate that apparently different problems have elements in common. Perhaps their most important use is to remove ambiguity (175).

What do studies of the college mathematics curriculum reveal?

The teaching demands of college staffs discourage experimentation and study of the college curriculum. However, a few colleges reported studies in this area.

A followup study found that graduates employed by industry or government were more critical of their college's mathematics curriculum than were the educators, but most graduates agreed that the advanced program in mathematics needed improvement (118).

One study revealed that about one-fifth of the teachers in small colleges held the Ph. D. degree. Because of the lack of well-prepared teachers the small colleges find it difficult to offer advanced courses in mathematics (38).

One investigator developed a process for the selection of content for a modern course in freshman mathematics (108). A required course in freshman mathematics and physics at Amherst College obtained experimental support (172), as did an integrated course in a 2-year community college (132).

It was recommended that, in a liberal arts college where mathematics is required for all students, a course be designed especially for the nonmathematics nonscience major (26).

What is the role of an editor in the production of arithmetic textbooks?

Little research has been done on this question. One recent study concludes that "As custodian of the publisher's investment in the arithmetic series, the editor is responsible for everything which contributes to producing textbooks which meet an educational need at the time that need is felt. As custodian of the author's interests, the editor is responsible for the best possible program as it performs in the classroom" (121).

Recommendations

Teams of Researchers.—Many research problems can only be solved by teams, but few of the studies reported were team efforts. It was unfortunate that considerable time and money were spent by a number of individuals on problems that were too big and too complicated for any one person; in such cases little or no progress was made other than meeting the requirements for a degree. Research by beginners and college staff should be coordinated, and teams of research workers should be drawn from more than one institution of higher learning. This recommendation holds high priority.

Identification of Crucial Problems.—Closely associated with the first recommendation is that crucial problems in mathematics education be identified. Many of the proposed research problems reported in this study were fuzzy in purpose and procedure. Some of the flaws were only minor ones, but many were symptomatic of a widespread misidentification of basic problems. Too much time has been spent on questions like, Is programed instruction better than teacher instruction? We know by now that there is no one best method for all pupils. The important question seems to be: How can programed instruction be used effectively with which topics and with which pupils?

The most able mathematics educators should identify specific, crucial problems and should distinguish those that should be attacked by teams from those that might best be studied by individuals. This identification could be made through conferences at the local, State, or National level, or through a basic research project.

Reporting of Research.—The third recommendation is that all research be clearly reported and that the pertinent research be given wide publicity.

Many of the studies reflected unrelated objectives and inadequately described procedures. Statistical treatment in many cases was not appropriate for the raw data. In some cases the conclusions did not follow from the given data, or perhaps the conclusions were valid but the results of the experimentation poorly described. To improve research in mathematics education, leaders in the field must become more critical of both the design and the reporting of studies.

Some of the studies containing mere compilations of existing data were never published. Others were outlines and proposals for mathematics courses confined to a few carbon copies. Unpublished research makes little, if any, improvement in the teaching of mathematics. Perhaps a professional organization such as the National Council of Teachers of Mathematics could stimulate better research by giving wide publicity to good unpublished studies.

Unanswered Questions

One of the recommendations made in this study is that crucial problems in mathematics education be identified by experts. Until these key questions are identified by recognized authorities and the findings made known, degree candidates, their advisers, and other researchers will continue to need assistance in the selection of problems for investigation. Despite the inadequacies, a listing of problems would be beneficial to this group and could be helpful to those who might undertake the task of identifying crucial issues.

The questionnaire used in this study asked the researcher to list one or two important questions still unanswered. Those that were reported usually related to the researcher's particular study; they varied greatly in type and significance. The questions are presented here with minor revisions, and a few deletions to avoid obvious repetition. No attempt has been made to classify or to list them in any order of significance.

1. Is there a mathematics readiness? If so, how can it be measured at the kindergarten level?
2. Is there a need for the development of tests to measure understanding of concepts at the various grade levels, including primary?
3. What effect has the early introduction of concepts upon the learner? Upon successive stages of the mathematics curriculum?
4. Should "modern" mathematics, or the traditional, or both be used at all levels of instruction?
5. What "modern" mathematics should be taught to which students?
6. What are the optimum factors that will encourage the development of valid tests to measure the outcomes of the "new" mathematics courses?
7. What is the validity of the various new topics included in "modern" mathematics courses?

8. Is it possible for children with IQ below 85 to understand place value?
9. How is achievement in mathematics related to personality factors outside the area of pure intelligence as measured by IQ?
10. What are the effects of subgrouping, the use of additional materials, and individualized techniques upon teaching at the various grade levels?
11. What is the role played by "discovery" in teaching? in learning?
12. What are the optimum methods for inducing and utilizing discovery? optimum time allotments?
13. Can enrichment and acceleration in mathematics be extended effectively to all grade levels?
14. Is there a basic structure to the system of traits of individuals so that they may be treated in a factor analysis?
15. What mathematical concepts best match the maturity level of the average high school student?
16. In heterogeneously grouped classes will "modern" mathematics or traditional mathematics best meet the needs of the pupils?
17. What motivational factors function most effectively with different ages, abilities, and personalities?
18. What is the correlation between verbal aptitude and achievement in mathematics?
19. What is the role of programed learning in the total instructional program?
20. What is the relative efficiency of the use of programed materials with students of different developmental levels, personalities, backgrounds, and aptitudes?
21. Are programed learning materials suitable only for a particular type of individual? If so, what are his characteristics?
22. What are the effects of programed learning on student attitudes, emotions, and patterns of behavior?
23. What is the effect on retention in other subject matter areas when each student is permitted to proceed at his own rate in one area?
24. What are the characteristics of those students best suited to pursue independent study of mathematics?
25. What are the components of mathematical maturity? What are their measures?

26. What terminal mathematics should be taught at which grade level?
27. What is a curriculum for ninth-grade "general mathematics" that would be useful? Effective?
28. In the traditional programs should geometry follow algebra II rather than algebra I?
29. What abilities or skills can be improved by the study of solid geometry?
30. What are the optimum grade placement, sequence, and prerequisites that will lead most efficiently to an understanding of the fundamental concepts of solid geometry?
31. What role does the student's self-concept play in his achievement in mathematics?
32. What are the implications of the self-concept theory for the development of course content in mathematics? Pedagogy?
33. Does forced verbalization of mathematical concepts develop blocks to later mathematical learnings?
34. What learning theory accounts for the differences in pupils that result in the group characterized as "low achievers"?
35. What are the large categories of low achievers for teaching purposes?
36. Does the learning pattern of "slow learners" differ only in degree from that of the average and the rapid?
37. Does the teaching machine have characteristics particularly useful in the instruction of the low achiever? If so, what practices will make its use more effective?
38. What plan of class organization is most appropriate for the low achiever in mathematics?
39. What is the role of concrete or manipulative materials in the learning of mathematics?
40. Is mathematical aptitude a single identity or a pattern of aptitudes?
41. What practical techniques are most useful for differentiating instruction to rapid and slow learners in heterogeneous classes?
42. What are the psychological principles that govern the learning of mathematics?
43. What kinds of emotional disturbance, if any, are specific to mathematics? What is their incidence in the school population? How may cause and effect in the situation be disentangled?

44. What are the minimal understandings of mathematics that should be acquired by all students?
45. What organization of mathematical content facilitates optimum learning?
46. How can the curriculum be made sufficiently flexible to meet the needs of the rapid, the average, and the slow learners?
47. How do words function in the learning and use of mathematical principles—when used as stimuli, as labeling responses, or as concepts?
48. Are there differences in the adequacy of words and visual models as mediators of rules and problem solving?
49. What is the process that accounts for the "dropping out" of verbal mediation in the solution of problems symbolically?
50. If words are used in mediating problem solving, what conditions determine the precise meanings for these words, so that they do not lead to errors in performance?
51. What kind of learning will provide capability for discovery?
52. What are the dimensions of novelty in problems? What makes a problem new as opposed to familiar?
53. For a given student, how can a teacher know when it is not too soon for him to verbalize a discovery?

Section II. DESCRIPTIVE LISTING

Cooperative Research Projects

The Cooperative Research Program of the U.S. Office of Education was authorized by Congress in 1954 under Public Law 531, which enables the Commissioner of Education to "enter into contracts and jointly financed cooperative arrangements with colleges, universities, and State education departments for the conduct of research, surveys, and demonstrations in the field of education." Funding of the program began in 1957. Projects supported by the program vary in size, scope, duration, and areas of study. More than 300 have now been completed. Seven of these dealing with mathematics are included in this listing. They are listed alphabetically by author, and are followed by a briefer listing of cooperative research in progress.

1. BOWIN, WILLIAM F. "Evaluation of the Madison Project Method of Teaching Arithmetic Situations, Grades Four, Five and Six." (1963, New York State Department of Education, Albany, N.Y.) Cooperative Research Project No. 1193.

Problem.—To evaluate the effectiveness of the Madison Project method of teaching arithmetic.

Procedure.—Twelve experimental classes taught by the Madison Project method were compared with 12 control classes taught by the method practiced in the Syracuse public schools. Classes consisted of fourth-, fifth-, and sixth-grade students. The duration of the experiment was one academic year. The experimental classes were taught the Madison Project material during one mathematics period per week.

Major Findings and Conclusions.—(1) Grade 4 classes, both control and experimental, showed considerable achievement gain over what might have been expected in terms of normal growth. Several of the experimental groups showed a significant gain on the Syracuse Test of Algebraic Fluency.

(2) In grades 5 and 6 the gains were less significant, although considerably beyond the expected achievement for both of these grades. The grade 6 groups, both experimental and control, showed a regression from the pre- to the post-testing on the Syracuse Test of Algebraic Fluency.

(3) Apparently students in the experimental groups increased their skill and understanding of complex mathematical presentations without losing any ability to be successful on conventional arithmetic achievement as measured by tests.

(4) The low groups in the experimental classes in grades 4 and 6 scored significantly higher than the low groups in the control classes. However, the low group in the control classes of grade 5 scored significantly higher than the experimental classes in every test area.

2. **Calandra, Alexander.** "A Project in the Teaching and Development of an Integrated Physics-Algebra Course at the Ninth Grade Level" (1959, Washington University, St. Louis, Mo.) Cooperative Research Project No. 403.

Problem.—To demonstrate and evaluate the merits of an integrated physics and mathematics program at the ninth-grade level.

Procedure.—The course was taught 5 days a week for 2 hours a day for 1 school year. Credit was given for 1 year of science and 1 year of algebra. The subject matter for the first semester was primarily geometric optics. Ratio and proportion were immediately introduced, with the treatment of signed numbers delayed until students had gained considerable facility in working with literal numbers. Similar triangles were introduced. The sine function was explored in terms of the unit circle concept. Mathematics for the second semester was developed around the concept of functions with a very elementary but integrated treatment of graphs, tables, and equations. The syllabus contained 26 units for the course.

Major Findings and Conclusion.—The conclusions were based upon this particular integrated mathematics-physics course, in which the instruction was directed by this supervisor-researcher.

(1) The teaching of physics and mathematics as integrated subjects produced a superior competence in algebra, as measured by standardized tests developed for conventional courses. It did not produce the same level of competence in physics by the same measure.

(2) The course can be successfully taught by a teacher of average competence, with an average (but not overly heterogeneous) student group, provided that lesson plans are available in considerable detail.

(3) The course has been well received by students of average ability, and particularly well received by students of above-average ability.

(4) Students who are taught physics and mathematics by the same instructor can cover substantially more material than those who are taught by two different instructors.

3. **Davis, Robert B.** "A Modern Mathematics Program as it Pertains to the Interrelationship of Mathematical Content, Teaching Methods and Classroom Atmosphere" (1963, Syracuse University, Syracuse, N.Y.) Cooperative Research Projects No. D-022 and D-044.

Problem.—To demonstrate some student experiences that reflect a valid interpretation of "good mathematical thinking."

Procedure.—The demonstration and its procedures were regarded as an exercise in evolution to develop a combination of attributes that together served to give children experience in good mathematical thinking. The procedures consisted of developing an organizational structure that provided competent personnel to teach or to supervise work in each participating school; arranging for project materials to be taught to children in grades 4, 5, 6, and 7 for approximately 1 hour per week; providing for weekly or biweekly inservice education for teachers in participating schools; accumulating a library of tape recordings of actual classroom lessons; analyzing selected tape-recorded lesson excerpts for identification of relevant factors in mathematical thinking, the classroom experience, and teacher effectiveness; accumulating a library of 16mm sound motion pictures recording actual classroom lessons; using these films as a means of reporting to the teaching and mathematics professions and as a means of teacher education; and consulting with professional leaders to guarantee the relevance and appropriateness of the learning experiences provided by the project.

Major Findings and Conclusions.—This report covers the first two years of a proposed 5-year activity. Evidence to date indicates that under certain conditions a significant fraction of fourth-, fifth-, sixth-, and seventh-graders can make creative use of the mathematical ideas presented in the Madison Project materials. Integration of such creative exploratory mathematical experiences into the school program can be achieved with reasonable success. The use of films as a means of recording classroom experiences appears to have many important advantages over most other methods of recording the desired information.

4. DuBois, Philip H. *and* Feierabend, Rosalind L. "Psychological Problems and Research Methods in Mathematics Training" (1959, Washington University, St. Louis, Mo.) Cooperative Research Project No. 642.

Problem.—To provide a handbook or guide for scientific investigators in mathematics education.

Procedure.—A Conference on Psychological Problems and Research Methods in Mathematics Training was the occasion for the presentation of 14 papers dealing with problem areas in the teaching of mathematics and 15 proposals suggesting research methods and designs for related studies. Psychological and educational literature of the years 1948–58 was reviewed to summarize the research relevant to the learning of mathematics at all academic levels.

Major Findings and Conclusions.—The final report contains the 29 papers presented at the conference and a summary of the research reviewed in a bibliography of 285 references.

The report has been published under the title "Research Problems in Mathematics Education," OE–12008, Cooperative Research Monograph No. 3. The 130-page monograph is available for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Price 55 cents.

5. Klausmeier, Herbert J. "An Analysis of Learning Efficiency in Arithmetic of Mentally Retarded Children in Comparison with Children of Average and High Intelligence" (1959, University of Wisconsin, Madison, Wis.) Cooperative Research Project No. 153.

Problem.—To provide information about the learning retention, physical achievement, and personality characteristics of mentally retarded children, in comparison with other children.

Procedure.—The subjects were three groups of 20 boys and 20 girls each. All of the 120 children had birthdays within a specified 15-month period, and were enrolled in the Madison and Milwaukee public schools. Low intelligence was defined as an IQ of 55 to 80, average intelligence as an IQ of 90 to 110, and high intelligence as an IQ of 120 or higher. Low-IQ children who exhibited readily observable symptoms of abnormality were excluded. The

120 children had a mean chronological age of 101 months and were in the third grade when the experiment began. The duration of the experiment was 3 years, with the first year being given to a pilot study.

Five types of measure were secured: (1) arithmetic learning retention, (2) physical (height, weight, strength of grip, dentition, and carpal age), (3) mental, (4) achievement (reading, arithmetic, language) and (5) personality measures of coordination and peer acceptance, which were secured for the final year.

Major Findings and Conclusions.—(1) The ratio between learning-relearning time was the same among children of low, average, and high intelligence. The rate of acquiring overall arithmetic learnings was much lower for the low-IQ pupils than for the other two groups. (2) Retention of arithmetic learning was the same among children of low, average, and high intelligence when the original learning task was graded to the learner's achievement level. (3) The hypothesis that uneven physical development within the child accompanies low efficiency in arithmetic achievement was not supported. The persistent trend of negative correlations suggest that this hypothesis is worth further investigation. (4) The hypothesis that a low level of physical development within the child accompanies low achievement in arithmetic and reading was rejected. (5) The within-child variability in strength of grip, intelligence, reading achievement, language achievement, and arithmetic achievement was not the same among children of low, average, and high intelligence; the average-IQ children showed less within-child variability than did the high- and low-IQ children, who were equally variable. (6) Chronological age showed no significant correlation with the other measures.

The researchers believe that the most important implication of the entire study is that classroom teachers should find out early in the school year the present achievement levels of the individual children in the class, should select learnings of the next higher levels of difficulty, and should offer individualized or small-group instruction to promote efficient acquisition and subsequent retention. The low-IQ children can acquire, although more slowly than the average- and high-IQ children, material that is graded to their level of difficulty and can retain what is acquired as well as children of average and high intelligence. Apparently, when an individual child has some confidence that he can successfully complete a learning task he has been presented with, no further motivational techniques are needed except perhaps partial reinforcement of correct response and approval of the teacher.

6. **Suppes, Patrick.** "Experimental Teaching of Mathematical Logic in the Elementary School" (1964, Stanford University, Stanford, Calif.) Cooperative Research Project No. D–005.

Problem.—To determine the difficulty and appropriateness of the learning of the elements of mathematical logic by gifted fifth- and sixth-grade students.

Procedure.—The first step was a pilot study in the teaching of mathematical logic to 25 students selected from several fifth-grade classes. The class met 3 days per week throughout the 1960–61 school year for 30-minute sessions. Explanatory materials and practice exercises were prepared for class use. During the summer of 1961 an extensive four-week course, using the materials developed for the students, prepared teachers to teach the course. Seventeen teachers enrolled in a second course in fall 1962 while they were teaching their own first- or second-year class in logic to fifth- or sixth-grade children.

In 1961–62, 12 classes of 350 fifth-grade students began their study of logic. Classes followed the textbook sequence, but no effort was made to maintain a uniform rate of progress within or among classes. In 1962–63, 11 classes of sixth-graders, 215 students in all, who had studied logic in the fifth grade continued with a second year of study of logic. Twelve new fifth-grade classes, 269 students in all began their first year of logic study.

Control groups were two Stanford University logic classes that used the text prepared for the elementary school students.

Series of tests were developed to be administered to the subjects upon their completion of designated units in the text.

Major Findings and Conclusions.—(1) The upper quartile of elementary school students achieved a significant conceptual and technical mastery of elementary mathematical logic. The level of mastery was 85 to 90 percent of that achieved by comparable university students. (2) This mastery was accomplished in an amount of time comparable to that needed by college students, but dispersed over a much longer period and augmented by considerably more direct teacher supervision. (3) The more dedicated and able elementary school teachers were given sufficient preparation in five or six semester hours of instruction to teach classes in elementary mathematical logic.

7. **SUPPES, PATRICK.** "The Development of Mathematical Concepts in Children" (1964, Stanford University, Stanford, Calif.) Cooperative Research Project No. 727.

Problem.—To describe the development of mathematical concepts in young children and explain the order and character of this development in terms of modern learning theory.

Procedure.—A variation of the stimulus sampling theory as first formulated by Estes was applied in a series of eight experiments. Subjects were children in kindergarten through third grade. Experiments dealt with binary numbers, equipollence and identity of sets, polygons and angles, variation in method of stimulus display, incidental learning, variation of response methods, logical abilities of young children, and mathematical proofs.

Major Findings and Conclusions.—Some of the tentative conclusions reached were that (1) formation of simple mathematical concepts in young children is approximately an all-or-none process; (2) learning is more efficient when a child who makes an error is required to make an overt correction response in the presence of the stimulus to be learned; (3) incidental learning does not appear to be an effective method of acquisition of concepts for young children; (4) contiguity of response, stimulus, and reinforcement enhances learning; (5) in the learning of related mathematical concepts the amount of overall transfer from the learning of one concept to another is surprisingly small; (6) transfer of a concept is more effective if the learning situation has required the subject to recognize the presence or absence of a concept in a number of stimulus displays, and if learning has involved matching from a number of possible responses; and (7) children in the primary grades already have a reasonably good mastery of hypothetical reasoning and their thinking is not naturally restricted to "concrete" operations.

Cooperative Research in Progress

BEBERMAN, MAX. "A Comparison Between Two Kinds of Secondary Mathematics Courses With Respect to Intellectual Changes" (University of Illinois, Urbana, Ill.) Cooperative Research Project No. 1566

BLAKE, KATHRYN A., ELLIS, ALTON A., FINDLEY, WARREN G., *and* WESTBROOK, HELEN R. "Organization of Mathematics in Grades 4, 5, and 6" (University of Georgia, Athens, Ga.) Cooperative Research Project No. 2531

BLOOM, BENJAMIN S. "Cross National Study of Educational Attainment: Secondary School Mathematics" (University of Chicago, Chicago, Ill.) Cooperative Research Project No. 1854

BORNSTEIN, HARRY. "Evaluation of High School Mathematics Programed Texts as Used With Deaf Students" (Gallaudet College, Washington, D.C.) Cooperative Research Project No. 1633

BROWNELL, WILLIAM A. "Arithmetical Abstractions: The Movement Toward Conceptual Maturity Under Differing Systems of Instruction" (University of California, Berkeley, Calif.) Cooperative Research Project No. 1676

CHILDS, GAYLE B. "Advanced Placement Program in High School Correspondence Study" (University of Nebraska, Lincoln, Nebr.) Cooperative Research Project No. 2010

COHEN, K. C. "Reactions of Students to Receiving Grades" (Johns Hopkins University, Baltimore, Md.) Cooperative Research Project No. S–129

DAVIS, ROBERT B. "A Modern Mathematics Program as it Pertains to the Inter-Relationship of Mathematical Content, Teaching Methods, and Classroom Atmosphere (The Madison Project)" (Webster College, St. Louis, Mo.) Cooperative Research Project No. D–093

GOLDBERG, MIRIAM L. *and* PASSOW, A. Harry. "Accelerated and Enriched Curriculum Programs for Academically-Talented Students (Mathematics)" (Teachers College, Columbia University, New York) Cooperative Research Project No. D–009

GUILFORD, J. P. *and* MERRIFIELD, PHILIP R. "Determination of Structure-of-Intellect Abilities Involved in Ninth-Grade Algebra and General Mathematics" (University of Southern California, Los Angeles) Cooperative Research Project No. 1342

HENRY, GEORGE H. *and* BROWN, JOHN A. "Concept Development in the High School Classroom" (University of Delaware, Newark, Del.) Cooperative Research Project No. 1487

JACKSON, DAVID M. (Part I) *and* SUCHMAN, J. RICHARD (Part II). Part I: "Secondary School Programs for Gifted Students in English, Social Science, Mathematics"; Part II: "Elementary School Programs in Scientific Inquiry for Gifted Students" (University of Illinois, Urbana, Ill., State Department of Public Instruction, Springfield, Ill.) Cooperative Research Project No. D–076.

KEISLAR, EVAN R. "Abilities of First Grade Pupils to Learn Mathematics in Terms of Algebraic Structures by Means of Teaching Machines" (University of California, Los Angeles, Calif.) Cooperative Research Project No. 1090

Miller, Vergil V. "Mathematical Models in Teaching Economics" (Eastern Washington State College, Cheney, Wash.) Cooperative Research Project No. S–187

Pate, R. T. *and* **Sloan, F. A.** "A Study of Teacher-Pupil Interaction Differences Between School Mathematics Study Group and Traditional Mathematics" (University of Oklahoma, Norman, Okla.) Cooperative Research Project No. S–137

Payne, Joseph. "Self-Selected Mathematics Learning Activities in Grade Seven and Eight" (University of Michigan, Ann Arbor, Mich.) Cooperative Research Project No. 2047

Rising, Edward J. "Effects of Pre-Freshman Orientation Experiences on Academic Progress" (University of Massachusetts, Amherst, Mass.) Cooperative Research Project No. S–151

Rosenbloom, Paul C. "Characteristics of Teachers Which Affect Students' Learning" (University of Minnesota, Minneapolis) Cooperative Research Project No. 1020

Ryan, James J. "Effects of Modern and Conventional Mathematics Curricula on Pupil Attitudes, Interest, and Perception of Proficiency" (Minnesota National Laboratory, State Department of Education, Minneapolis, Minn.) Cooperative Research Project No. 2747

Shockley, W. "Teaching Scientific Thinking at the High School Level" (Stanford University, Stanford, Calif.) Cooperative Research Project No. S–090

Suppes, Patrick. "Development of Mathematical Concepts in Children" (Stanford University, Stanford, Calif.) Cooperative Research Project No. 1616

Suppes, Patrick *and* **Atkinson, Richard C.** "An Automated Primary Grade Reading and Arithmetic Curriculum for Culturally Deprived Children" (Stanford University, Stanford, Calif.) Cooperative Research Project No. H–130

Sutton, Joseph T. "Individualizing Junior High School Mathematics Instruction" (Stetson University, De Land, Fla.) Cooperative Research Project No. 1365

Way, Frederick *and* **Saul, W. E.** "Utilization of Computer Facilities in the Mathematics and Business Curriculum in a Large Suburban High School" (Case Institute of Technology, Cleveland, Ohio) Cooperative Research Project No. S–232

Westbrook, Helen R. *and* **Blake, Kathryn.** "Examination of Intellectual Processes Related to Mathematics Achievement at Grade Levels 4, 5, and 6" (University of Georgia, Athens, Ga.) Cooperative Research Project No. S–046

Zimiles, Herbert. "The Development of Differentiation and Conservation of Number" (Bank Street College of Education, New York) Cooperative Research Project No. 2270

Other Projects

Like the Cooperative Research projects, the descriptions of the following research projects are listed alphabetically by author, or when there is more than one, by senior author.

The name of the major faculty adviser is listed for those degree studies for which the information was furnished.

8. ALEXANDER, FORREST DOYLE. "An Experiment in Teaching Mathematics at the College Level by Closed-Circuit Television" (Ph. D., 1961, George Peabody College for Teachers, Nashville, Tenn.).

Major Faculty Adviser.—J. Houston Banks.

Problem.—To compare the effects of the same lectures in college mathematics when presented over closed-circuit television or by an instructor in the classroom.

Procedure.—The subjects consisted of all students who registered for a course in fundamental mathematical concepts at George Peabody College during two consecutive quarters. The experiment necessitated the conducting of a pilot study in addition to the experiment. During each quarter in which the study was conducted, all students registering for this course were divided into four sections (A, B, C, and D) by a randomized procedure. Two sections, A and B, were located in classrooms equipped with two television sets. Both sections received a 30-minute lecture over closed-circuit television. The remaining part of the period was devoted to clarifying and supplementing the lecture, with section A receiving this instruction by someone other than the television instructor while section B was taught by the television instructor.

Sections C and D were located in a large classroom equipped with a folding partition which enabled the sections to be separated during the latter part of the period. Both sections received a 30-minute live presentation by an instructor following the same outline as used in the television lecture presented to sections A and B. Four instructors were necessary since all four sections were taught during the same hour.

A pilot study to determine the reliability of the achievement test used in the experiment showed a reliability coefficient of 0.90 as indicated by the Pearson product-moment correlation coefficient adjusted by Guttman's Formula.

Major Findings and Conclusions.—(1) The delivery of comparable lectures, either by television or in person, seemed to produce comparable learning. (2) The fact that during the followup period a different instructor presented approaches to the mathematical topic other than those presented in the television lecture did not significantly alter the achievement obtained. (3) Student achievement was not affected by any particular combination of mode of instruction, closed-circuit television or live lectures, or the use of one or two instructors in each class period.

9. ASHER, J. WILLIAM. "Predicting Students' Success in First-Year Algebra" (1962, University of Pittsburgh, Pa.)

Problem.—To determine the best predictors of student success in first-year algebra.

Procedure.—The data from 11 available variables were taken from the school records of 192 students from 2 junior high schools. The variables were the seventh-grade mathematics mark, eighth-grade mathematics mark, seventh-grade reading mark, eighth-grade reading mark, raw score or IQ test given during eighth grade, grade equivalent on arithmetic achievement test total score given during seventh grade, grade equivalent on arithmetic achievement test total score given during eighth grade, grade equivalent on reading part of achievement test given during seventh grade, grade equivalent on reading part of achievement test given during eighth grade, and raw score on algebra prognostic test given during eighth grade. Marks in first-year algebra were the criterion of success. The data were punched onto cards, and an IBM 7070 was used to compute the intercorrelation matrix and 55 correlations along with the means and standard deviations of all variables.

Major Findings and Conclusions.—The best single predictor of success in algebra in this school system was the eighth-grade mathematics mark. The only other factor which greatly raised the multiple correlation was the grade equivalent on the arithmetic part of the achievement test given near the end of the seventh grade.

10. Ashton, Sister Madeleine Rose. "Heuristic Methods in Problem Solving in Ninth Grade Algebra" (Ph. D., 1962, Stanford University, Palo Alto, Calif.).

Problem.—To test the effectiveness of teaching verbal problems in ninth-grade algebra by the heuristic method.

Procedure.—The subjects were 243 students in 5 high schools. In each school one class was taught by the heuristic method, and another by the textbook method. In the experimental classes using the heuristic method, the teachers insisted that the students ask themselves key questions such as, What is the unknown? What are the data? What are the conditions? Pre- and post-tests consisting of verbal problems similar to those found in standard algebra tests were administered.

Major Findings and Conclusions.—For the sample studied, the heuristic method was superior.

11. Balomenos, Richard Herbert. "An Experimental Study Comparing the Effectiveness of Teaching Deduction in Two Content Areas of Secondary Mathematics" (Ed.D., 1961, Harvard University, Cambridge, Mass.).

Major Faculty Adviser.—John W. M. Whiting.

Problem.—To compare the effectiveness of teaching deduction in algebra and in geometry.

Procedure.—Six intact classes of 10th-grade mathematics students were divided into 2 groups of 3 classes each. Three teachers each taught a class from each group. In one group, emphasis was placed on the basic structure of the number systems—natural numbers, integers, rational numbers, and the real number system. Students proceeded deductively from the axioms which characterize natural numbers to the properties for the real numbers. The other group studied geometry using the SMSG geometry text.

Paper and pencil tests designed to evaluate the hypotheses were used as pre- and post-tests. Standardized achievement tests were also used.

Major Findings and Conclusions.—The students taking the deductive number system course did not have a better understanding of the deductive nature of mathematics than the students taking geometry.

12. **Bandy, Anna Grace.** "A Mathematics Follow-Up Study of Selected White County High School Graduates" (M.A., 1961, Tennessee Polytechnic Institute, Cookeville).

Major Faculty Adviser.—E. Oriole Wisner.

Problem.—To determine the relationship among selected variables as criteria for success in college mathematics.

Procedure.—Variables selected for study were the number of units of credit in high school mathematics units, courses and grades earned in each, scores on the college mathematics placement test, grades earned in college mathematics, and the IQ's. The population included the graduates of White County High School who attended Tennessee Polytechnic Institute during the years 1950–58 inclusive.

The standard formulas for measures of central tendency, standard deviation of probable error, the Bravais-Pearson method of determining the coefficient of correlation, and the Holzinger rules of significance were used in analyzing the variables.

Major Findings and Conclusions.—(1) The high school mathematics background was the most valuable criterion for predicting success in college mathematics. (2) Marks earned in college mathematics were usually one letter grade lower than marks earned in high school mathematics. (3) IQ's had only a slight relationship to grades in high school or college mathematics.

13. **Barnes, James W.** "A Study to Determine the Adequacy of Teacher Observation as a Method of Attitude Appraisal in Seventh-Grade Mathematics" (M.Ed., 1962, West Chester State College, West Chester, Pa.).

Major Faculty Adviser.—Albert E. Filano.

Problem.—To determine the adequacy of teacher observation as a method of appraisal of students' attitudes toward mathematics.

Procedure.—Involved in the study were 370 seventh-grade students. Teacher ratings of the attitudes of these students made on a 5-point scale were compared with the students' attitudes as measured by the Remmers' Attitude Scale.

Major Findings and Conclusions.—Teacher observations are an inadequate method of appraisal of students' attitudes toward mathematics.

14. **Belcastro, Frank P.** "Programed Learning: Relative Effectiveness of Four Techniques of Programing the Addition and Subtraction Axioms of Algebra" (Ph. D., 1961, University of Pittsburgh, Pa.).

Major Faculty Adviser.—Peter T. Hountras.

Problem.—To determine the relative effectiveness of four techniques of programing the addition and subtraction axioms of algebra.

Procedure.—The four techniques were combinations of inductive and deductive methods of programing with verbal and nonverbal modes. Five treatment groups were equated. Four of the groups were each assigned one of four programs, each using a different technique. The fifth group was a nontechnique control group.

Major Findings and Conclusions.—Each technique was significantly better than no technique in teaching the axioms and in aiding subjects to apply these axioms to original problems. The verbal deductive technique was found to be superior to the other three. Differences among the other three techniques were not significant.

15. **Berenson, Lewis Jay.** "The Adaptation of High School Mathematics to Mass Education: 1915 to 1925" (Ph. D., 1961, Teachers College, Columbia University, New York).

Major Faculty Adviser.—Howard F. Fehr.

Problem.—To study the changes in content, organization, and sequence of high school mathematics between 1915 and 1925.

Procedure.—A search was made of the literature pertinent to the topic.

Major Findings and Conclusions.—The study reveals that the offerings in grades 7 through 9 were reorganized to accommodate the broader span of intellectual abilities which equalization of opportunity had produced. The trend was to make content more interesting, to facilitate comprehension, and to stress common applications of mathematics. Little revision of content occurred beyond grade 9, where the purpose of instruction was primarily college preparatory. An appraisal of the changes points up the difficulties encountered in introducing innovations into the curriculum.

16. **Berger, Emil J.** "An Investigation of the Effectiveness of Televised Presentations of Self-Contained Television-Adapted Lessons on Enrichment Topics in Mathematics" (1962, University of Minnesota, Minneapolis).

Major Faculty Adviser.—Donovan A. Johnson.

Problem.—To determine the effectiveness of televised presentations of lessons on enrichment topics in mathematics.

Procedure.—The study involved 154 ninth-grade algebra students from 5 classes that were available for viewing television, 57 10th-grade geometry students from 2 classes that were available for viewing television, and 58 10th-grade geometry students from 2 classes that were available for face-to-face teaching. Three of the ninth-grade classes were heterogenous, one was a homogeneously grouped high-ability class, and one a homogeneously grouped low-ability class.

Eight self-contained television-adapted lessons on enrichment topics in mathematics were used as instructional units. A separate multiple-response test written for each lesson was used as a pretest and post test. Ninth-grade algebra and 10th-grade geometry students followed a 3-day pretesting/viewing/posttesting sequence. Tenth-grade geometry students available for face-to-face instruction followed a similar 3-day routine. All instruction was conducted by the investigator.

Major Findings and Conclusions.—Homogeneously grouped high-ability students achieved significantly better than high-ability students from heterogeneous classes on three television lessons out of seven. Low-ability students from heterogeneous classes did significantly better than homogeneously grouped low-ability students on one television lesson out of seven.

Students who were taught face to face achieved significantly better than television-taught students on two lessons of the seven, and television-taught students were significantly superior on one lesson of the seven.

17. **Binster, Alfred Rudolph.** "A Comparison of Two Methods of Teaching the First Case of Per Cent" (Ed. D., 1961, University of Kansas, Lawrence).

Problem.—To compare the effectiveness of two methods of teaching the first case of percent to sixth-grade pupils.

Procedure.—The sample consisted of 15 classes of sixth-grade pupils in an elementary school district in Kansas. After pooling assumptions were met, the original sample reduced to 6 classes of 152 pupils in the control group and 4 classes of 85 pupils in the experimental group.

The control group used the conventional method of teacher telling, demonstrating, explaining, and the textbook as the method of presenting arithmetical understandings and computational skills. The experimental group used a prescribed curriculum which stressed pupil self discovery, i.e., pupils were encouraged to explore, experiment, and discover for themselvs arithmetic facts and generalizations and various problem-solving techniques.

Major Findings and Conclusions.—(1) No significant difference in performance on the post test was found. (2) Mean performance on the retention test favored the experimental group at the 5 percent level of confidence.

18. **Bolser, Frank Curtis.** "Education in the Field of Mathematics in the U.S.S.R." (Ed.D., 1959, University of Florida, Gainesville).

Problem.—To describe mathematics education in the U.S.S.R.

Procedure.—The study was limited to the primary-secondary school, which includes grades K–10. A brief background of Soviet educational philosophy, policy, and organization was presented. A consideration of the mathematics curricula includes a discussion of course content, time requirements, textbooks, classroom equipment, examinations, and homework.

Major Findings and Conclusions.—The summary reveals the Soviet concentration on scientific and technical training based on a curriculum of arithmetic, algebra, geometry, and trigonometry required of all secondary school graduates. Only the more gifted graduates are selected to attend the colleges and institutions; this selection is made by a series of comprehensive examinations.

19. **Braun, Frederick George.** "The Extent to Which Selected Arithmetical Concepts and Skills Can Be Developed in First-Grade Children" (Ed. D., 1962, University of California, Los Angeles).

Major Faculty Adviser.—Wilbur H. Dutton.

Problem.—To determine the extent to which selected concepts and skills can be developed in first-grade children.

Procedure.—Two groups of 77 pupils each were matched on the basis of age, sex, intelligence, socioeconomic level, and initial arithmetic knowledge. Each group was divided into levels of intelligence so that each level had the same percentage of pupils as was contained in the general population of the school district. An advanced arithmetic program was administered to one group and their achievement compared with that of the matched control group.

Major Findings and Conclusions.—The experimental group made significantly greater gains. The difference was attributed to superior performance in computational skills. No significant difference was evidenced on the concept items.

20. **Brockman, Harold William.** "A Critical Study of the Use of the Terms 'Necessary Conditions' and 'Sufficient Conditions' in the Teaching of Mathematics" (Ph. D., 1962, Ohio State University, Columbus).

Major Faculty Adviser.—Nathan Lazar.

Problem.—To formulate clear and precise definitions for "sufficient conditions" and "necessary conditions" and to present methods for proving that a set of conditions is sufficient or necessary for a conclusion.

Procedure.—A test was administered to 187 people who were either experienced teachers of mathematics or undergraduate teacher trainees to determine how well they were acquainted with these topics. Textbooks from five areas of mathematics, books on methods of teaching mathematics, reports of commissions, books on logic, and articles in various periodicals were examined for definitions of "sufficient conditions" and "necessary conditions" and for discussions and explanations of their usage.

Major Findings and Conclusions.—A large percentage of those tested were unsure of the terms "sufficient conditions" and "necessary conditions." More of them were able to determine when conditions were sufficient than when they were necessary.

The authors of mathematics textbooks have done little to help students understand this topic. The use of this terminology becomes more prevalent as the student progresses. Authors of plane geometry texts make the most effort to aid the student in understanding these concepts. There is more agreement among authors in their definition of a sufficient condition than a necessary condition.

21. **Brown, Edward Dietz.** "Arithmetical Understandings and Attitudes Toward Arithmetic of Experienced and Inexperienced Teachers" (Ed. D., 1961, University of Nebraska Teachers College, Lincoln).

Major Faculty Adviser.—Leslie L. Chisholm.

Problem.—To determine the arithmetical understandings and attitudes of a selected group of inservice and prospective teachers of arithmetic.

Procedure.—The elementary education graduates of the University of Nebraska in 1959 were chosen as the prospective teachers. A similar number of experienced teachers was selected from those persons attending the university during the 1959 summer session. Glennon's Test of Basic Mathematical Understandings and Dutton's Attitude Toward Arithmetic Scale were administered.

Major Findings and Conclusions.—(1) Experienced teachers have a better grasp of basic mathematical concepts than prospective teachers. (2) Increased achievement does not appear to result from the number of years taught. (3) Teachers who studied mathematics in college have a better grasp of basic mathematical concepts than those who did not. (4) Concepts difficult for experienced teachers are also difficult for inexperienced teachers. Among the difficult concepts are the processes of decimal fractions and the rationale of computation. (5) Teachers who have taught arithmetic have a more favorable attitude toward it than those who have not taught it. (6) Most teachers reflect attitudes toward arithmetic ranging from favorable to neutral. (7) Teachers who have a high degree of understanding of the basic concepts have a positive or favorable attitude toward the subject.

22. **Burke, Gerald Edward.** "Discovery Methods for Teaching Mathematics" (M.S., 1961, University of Utah, Salt Lake City).

Major Faculty Adviser.—Stanley M. Jencks.

Problem.—To study "discovery" methods as an instructional approach for use in junior high school that might minimize the number of students turning away from mathematics.

Procedure.—Descriptions and examples of the inductive, nonverbal awareness, and incidental methods were presented. One chapter contained examples of mathematical concepts developed by use of the nonverbal awareness discovery method and in sufficient detail for classroom use.

Major Findings and Conclusions.—The author concluded that the nonverbal awareness method is the most effective. The teacher with a good mathematics background is more likely to be successful with the discovery method.

23. **Campo, Vito David.** "An Evaluation of the Effectiveness of the Modified Geometry Program Proposed by the CEEB as Compared with the Traditional Geometry Program" (M. Ed., 1962, Rhode Island College, Providence).

Major Faculty Adviser—Stanley B. Trail.

Problem.—To evaluate the effectiveness of the modified geometry program proposed by the CEEB as compared with the traditional geometry program.

Procedure.—An experimental class of 24 students was taught the modified geometry, and a control class of 26 students was taught the traditional geometry. Both classes were taught by the investigator. The ACE Coop Plane Geometry Test and Otis Quick Scoring Mental Ability Test were administered to both groups.

Major Findings and Conclusions.—No significant difference in achievement between the two groups was found.

24. **Carroll, Emma C.** "A Study of the Mathematical Understandings Possessed by Undergraduate Students Majoring in Elementary Education" (Ed. D., 1961, Wayne State University, Detroit, Mich.).

Major Faculty Adviser.—Charlotte Junge.

Problem.—To determine the mathematical understandings which the teacher of elementary arithmetic should have, to develop a test instrument to measure possession of these, and to make a diagnostic survey of the understandings of a group of preparatory teachers.

Procedure.—A list of mathematical understandings was tabulated from five leading textbook series. The list of understandings which the elementary teacher should have was validated by 13 mathematics education authorities. A two-form, multiple-choice objective test was designed to measure each understanding separately. The 178-item test was administered to a cross-section of 317 elementary education students at 5 educational levels at Wayne State University.

Major Findings and Conclusions.—(1) The students who were tested possessed a few more than half of the understandings agreed upon by the experts as needed by elementary arithmetic teachers. (2) The students were weak in understanding fraction, decimal, percent, and mensuration process.

25. **Chatterly, Louis Joseph.** "An Introduction to Set Theory for Teachers of Secondary School Mathematics" (M.S., 1962, University of Utah, Salt Lake City).

Major Faculty Adviser.—L. Edwin Hirschi.

Problem.—To develop an introduction to set theory for secondary school teachers.

Procedure.—Basic terms were discussed and defined. Many fundamentals were introduced through the use of finite sets. The equivalence of sets, the cardinal numbers, denumerable and nondenumerable sets, and the "problem of the continuum" were discussed.

Major Findings and Conclusions.—Material was produced which the investigator concluded would be of value to teachers with little knowledge of set theory.

26. **Clark, Marion Elmo.** "A Critical Analysis of the Objectives and Content of Mathematics for Liberal Education at the College Level" (Ed. D., 1962, University of Virginia, Charlottesville).

Major Faculty Adviser.—William C. Lowry.

Problem.—To analyze critically the objectives and content of mathematics for liberal education at the college level for students majoring in fields other than mathematics or science.

Procedure.—The objectives of liberal education as found in the literature were summarized under the headings of (1) knowledge, (2) intellectual abilities and skills, and (3) a sense of values. The objectives of mathematics for liberal education as found in the literature, in textbooks, and in descriptions of courses were summarized under headings (1) and (2) above.

Major Findings and Conclusions.—A review of the literature revealed a trend away from courses *about* mathematics toward courses *in* mathematics. There was lack of agreement on the desirability of offering courses for both specialists and nonspecialists and about appropriate content for the latter group. It was recommended that colleges which require all liberal arts students to study mathematics offer the nonmathematics, nonscience majors a course specially designed for them.

27. **Clark, Rose Velma.** "A Study to Measure Pupils' Comprehension of the Basic Arithmetic Concepts and Processes Taught in the Third Grade" (M.A., 1961, University of California, Los Angeles).

Major Faculty Adviser.—Wilbur H. Dutton.

Problem.—To help construct a valid and reliable test to measure pupil understandings of basic arithmetical processes, and to identify some of the main difficulties and achievements of children in third-grade arithmetic.

Procedure.—A test was constructed to measure pupils' comprehension of basic arithmetical concepts and processes taught in the third grade. A study of commonly used textbooks and the use of a group of experts established the curricular validity of the test.

The California Achievement Test, Reasoning Section, Form W, and the University of California Third Grade Comprehension Test were administered to 256 third-grade pupils.

Major Findings and Conclusions.—Ninety percent or more of the pupils correctly answered 11 test items treating place value of whole numbers, counting, understanding addition and subtraction processes, telling time, shape of a triangle, linear measure, and understanding of U.S. money. Serious difficulties were revealed in understanding the "clue" in a written problem in addition, carrying in addition, regrouping in subtraction, and seasons of the year.

28. **Cleveland, Gerald Arthur.** "A Study of Certain Psychological and Sociological Characteristics as Related to Arithmetic Achievement" (Ed. D., 1961, Syracuse University, Syracuse, N.Y.).

Problem.—To discover significant differences in certain psychological and sociological characteristics between the top quarter and bottom quarter of arithmetic achievers at the sixth-grade level.

Procedure.—One part of the study was based on sex differences, the other on socioeconomic differences. Within each of these there were three separate substudies, one in arithmetic fundamentals, one in concepts, and one in problem solving. The pupils were classified into high and low achievers by taking the top 25 percent and the low 25 percent of achievers in each of the three aspects of arithmetic separately and controlling for IQ and socioeconomic status or sex.

Major Findings and Conclusions.—(1) There were very small differences in arithmetic achievement between the sexes in fundamentals, concepts, or problem solving. (2) The higher socioeconomic environment of the school community has a positive relationship to achievement in the three aspects of arithmetic and at all IQ levels studied.

29. **COLWELL, GERALD A.** "A Unit on Numeral Systems for Ninth Grade General Mathematics" (M.S., 1962, University of Kansas, Lawrence).

Major Faculty Adviser.—Gilbert Ulmer.

Problem.—To prepare a unit on various numeral systems to be useful in a ninth-grade class in general mathematics.

Procedure.—The unit begins with a brief consideration of Roman, Mayan, Egyptian, and Babylonian numeral systems. The Hindu-Arabic system with emphasis on the positional principle follows. Systems with bases of 7, 2, and 12 are presented, with most time being given to base 2.

The author taught the unit in several classes in ninth-grade mathematics over a 3-year period.

Major Findings and Conclusions.—Student attitude toward computation was improved because of the shift of emphasis from drill to number representation in the different numeral systems.

30. **CONNELLAN, MIRIAM ELIZABETH.** "The Content of Secondary School Mathematics Courses Taught in Colorado by Teachers Who Attended the 1957–58 and the 1958–59 Colorado Academic Year Institutes" (Ed. D., 1962, University of Colorado, Boulder).

Major Faculty Adviser.—Harold M. Anderson.

Problem.—To contrast the content of mathematics courses taught by graduates of academic year institutes with the content of those taught by a matched group of 17 nonacademic year institute teachers.

Procedure.—Teachers were matched on school enrollment, degrees held, mathematics credits earned, and number of years of teaching experience. Information was obtained by recorded personal interviews with each teacher in his school.

Major Findings and Conclusions.—The Colorado AYI program has led more teachers to (1) enrich course content by including set theory, real number system, and non-Euclidean geometry; (2) place less dependence on the textbook; (3) be aware of the efforts to reorganize the mathematics curriculum, and (4) be aware of the importance of professional organizations to keep abreast of developments in mathematics.

31. **DAVIS, BETTY.** "The Effects of Reinforcement in Teaching Arithmetic on the Performance of Fifth-grade Students" (Ed. D., 1961, The Pennsylvania State University, University Park).

Problem.—To investigate the effects of different schedules of reinforcement on the learning of arithmetic in fifth-grade classrooms.

Procedure.—Three groups of fifth-grade pupils, each group working at separate times under a fixed-ratio schedule of reinforcement, a fixed-interval schedule, and a schedule of nonreinforcement were used to determine the proportional accuracy of arithmetic skills and retention of subject matter. The study extended over a 9-week period. Each group followed a specific schedule of reinforcement for each 3-week interval, which ended with a test. Three months later, the groups were retested for retention of material learned.

Major Findings and Conclusions.—Arithmetic material learned under a fixed-ratio schedule of reinforcement is retained longer than arithmetic material learned under either a fixed-interval schedule or a schedule excluding reinforcement. The results of the retention test corroborate this finding.

32. DAVIS, O. L., JR. *and* TRACY, NEAL H. "Arithmetic Achievement and Instructional Grouping" (1962, University of North Carolina, Chapel Hill).

Problem.—To compare arithmetic achievement in a Joplin-type plan of grouping with that in a random grouping.

Procedure.—The study involved 393 pupils in grades 4, 5, and 6 of 2 elementary schools. Students attending both schools were from similar social and economic sections of the community. Pupils in school A were specifically grouped for arithmetic instruction on the basis of ability and past achievement. Pupils in school B received arithmetic instruction from the teachers of their self-contained class.

Major Findings and Conclusions.—The initial advantage in arithmetic achievement in computation and reasoning by grouped pupils was neither maintained nor increased during the year's instructional period. The randomly grouped pupils made significantly greater gains in computation and reasoning. Girls made significantly greater gains in computation than boys but no significant differences were noted in reasoning.

33. DESSART, DONALD J. "A Study of Programed Learning with Superior Eighth Grade Students" (Ph. D., 1961, University of Maryland, College Park).

Major Faculty Adviser.—John R. Mayor.

Problem.—To determine (*a*) if superior eighth-grade students could achieve understanding of elementary aspects of the convergence and divergence of infinite series, and (*b*) which of seven study procedures would result in best understanding.

Procedure.—The seven study procedures were a teacher-taught procedure and six variations of programed learning: (*a*) linear program, single mode, with teacher aid, (*b*) branch program, single mode, with teacher aid, (*c*) branch program, single mode, without teacher aid, (*d*) linear program, full mode, without teacher aid, (*e*) branch program, full mode, without teacher aid, and (*f*) linear program, single mode, without teacher aid. Eighty students were assigned by a randomization procedure to seven groups.

Major Findings and Conclusions.—Students did achieve a satisfactory understanding of the elementary aspects of convergence and divergence of infinite series. The linear program was superior to the other methods when both the post-test and time criteria were considered.

34. **Dewar, John Alexander.** "An Experiment in Intra-Class Grouping for Arithmetic Instruction in the Sixth Grade" (Ed. D., 1961, University of Kansas, Lawrence).

Problem.—To determine whether intraclass grouping for arithmetic instruction results in significantly better achievement than the traditional whole-class grouping.

Procedure.—Eight sixth-grade classes were used, four as experimental and four as control. On the basis of achievement-test results, teacher opinion, and certain school records, the experimental classes were each divided into three groups: high, middle, and low. Appropriate and varied textbook materials and a curriculum outline prepared by the investigator for each group were provided for teachers of the experimental groups. The control classes were taught as a whole group using the sixth-grade textbook material. Teaching time was kept constant for control and experimental classes.

Major Findings and Conclusions.—The experimental classes made significant achievement gains over the control classes. The high and low groups in the experimental classes made significant gains over their counterparts in the control classes. Differences were significant at the 5 percent level.

35. **Dixon, William O.** "Incorporating Recent Proposals for Improvement of Geometry Instruction with the Instruction Based on the Traditional Textbook" (M.S., 1961, University of Kansas, Lawrence).

Major Faculty Adviser.—Gilbert Ulmer.

Problem.—To develop a pattern for incorporating recommended changes in geometry instruction into the traditional course.

Procedure.—Professional publications were analyzed to determine recommended changes, which were then used as a basis for the proposed pattern.

Major Findings and Conclusions.—A thorough discussion of deductive reasoning should follow the review of intuitive geometry. Discussion of the deductive system should emphasize the need for undefined terms. Postulates should be introduced including any additional ones needed to make the study more rigorous. The basic ideas of coordinate geometry should follow the first major group of theorems. Thereafter proof by either analytic or synthetic methods would be acceptable and occasionally both methods would be required on specific proofs. Selected topics of solid geometry should be intuitively considered with corresponding topics of plane geometry.

36. **Dominy, Mildred McCoy.** "A Comparative Analysis of European and American Elementary School Mathematics Textbook Programs" (Ph. D., 1962, Syracuse University, Syracuse, N.Y.).

Problem.—To make a comparative analysis of the content of elementary mathematics textbooks used in the United States and in selected European countries.

Procedure.—Texts that are ordinarily used with pupils up to 11 years of age were read for data and developmental steps related to the following topics: number system, arithmetic vocabulary and terminology, addition, subtraction, multiplication, and division of whole numbers, common and decimal fractions, money and percent, measurement, geometry, problem solving, and literal and directed numbers.

Major Findings and Conclusions.—If there is any "demonstrated superiority" of European children in arithmetic performance, it is not due to any more intensive textbook program.

37. **Doney, John Clifford.** "A Comparison of the Results in Pupil Achievement Obtained When Units of Mathematics Are Taught by Student Teachers and Inservice Teachers" (M. Ed., 1962, Indiana State College, Indiana, Pa.).

Major Faculty Adviser.—James E. McKinley.

Problem.—To compare mathematics achievement when mathematics units are taught by student teachers and inservice teachers.

Procedure.—Personnel of the study include 4 student teachers, 4 inservice teachers, and 172 pupils in 8 groups. These eight groups were divided into four pairs matched for subject matter to be taught, IQ, achievement, sex, course pursued, and grade in school. The selection of student teachers was a random one, depending entirely on their assignments from their respective colleges. No attempt was made to rate the inservice teachers. After one semester a post test was administered to determine the pupils' achievement.

Major Findings and Conclusions.—There was significant mathematical achievement in each group, but no significant difference in achievement between the pupils taught by the student teacher and those taught by the inservice teacher.

38. **Drew, J. William.** "The Mathematics Curriculum in the Small College" (1962, Virginia Union University, Richmond, Va.).

Problem.—To survey mathematics offerings in small colleges.

Procedure.—Questionnaires on courses offered in mathematics, number of required hours for a major in mathematics, and number of mathematics teachers and their earned degrees were sent to 35 small colleges.

Replies were returned by 27, none of which had graduate departments but each of which was a fully accredited college.

Major Findings and Conclusions.—Twenty-two percent of the teachers in these colleges held the Ph. D. degree, 70 percent the master's degree, and the remainder a bachelor's degree. The average number of semester-hours required for graduation for a major in mathematics was 30.6.

More than 20 of the colleges reported offering courses in differential equations, college algebra, modern algebra, calculus, advanced calculus, trigonometry, and theory of equations. Fewer than 15 offered mathematics of finance, college geometry, vector analysis, analytic geometry and calculus. Fewer than 10 offered mathematical analysis, programing for digital computers, theory of numbers, probability, or matrix theory.

39. **Dwight, Leslie A.** "An Abstract Approach to the Study of Fractions for Fifth and Sixth Grade Students" (Southeastern State College, Durant, Okla.).

Problem.—To develop a unit on common fractions for the fifth grade.

Procedure.—Attempt was made to write the material so that teachers might lead pupils to discover the answers. The introduction presented brief explanations of terms used, including the commutative, associative, and distributive properties; closure, identity elements for addition and multiplication; and the inverses for addition and multiplication. Multiplication of common fractions used the multiplicative inverse as the abstract approach to the operation. Applications were then made to the operations of addition and division of common fractions.

The unit was taught to fifth-grade students.

Major Findings and Conclusions.—Most of the pupils learned to manipulate fractions, and some recognized that [illegible] procedures were based on fundamental principles. Although the unit was taught with success in 6 to 10 40-minute periods, greater success might be obtained if the unit were spread over several weeks.

40. **Edwards, Charles W., jr.** "A Test of Arithmetic Principles, Elementary Form" (Ed. D., 1962, Indiana University, Bloomington).

Major Faculty Adviser.—Ronald C. Welch.

Problem.—To construct and standardize an evaluative instrument to measure comprehension of selected principles of mathematics by children in grades 3–6.

Procedure.—Current literature was surveyed to select the principles to be included in the test. Eighty-four original items were constructed. Four different revisions were made prior to submission of the tentative test to a panel of 19 authorities. A fifth revision, made according to the consensus of the experts, resulted in a 48-item, objectively scored, multiple-choice test. The scores of 1,500 children in grades 3–6 were then used to determine reliability, discriminatory power of the items, and percentile ranks for each grade level.

Major Findings and Conclusions.—The test appeared to be a valid and useful evaluative instrument. The items were distributed as follows: place value, 17; ordinal concept, 6; reading and writing numerals, 5; commutative principle, 6; associative principle, 5; distributive principle, 5; and identity elements, 4.

41. **Ellingson, James B.** "Evaluation of Attitudes of High School Students Toward Mathematics" (Ed. D., 1962, University of Oregon, Eugene).

Major Faculty Adviser.—J. Francis Rummel.

Problem.—To develop an instrument to identify the attitudes of high school students toward mathematics.

Procedure.—The "Mathematics Attitude Inventory" was constructed using the Thurstone method of attitude scaling. Fifty scaled statements were selected to form two equivalent scales—from extremely negative through neutral and from neutral through extremely positive. Classroom teachers administered the inventories to 755 students in 31 mathematics classes. Teacher ratings of student attitudes and current grades in each class were reported. Measures of mental ability, standard scores, and percentile ranks on Iowa Test of Educational Development (ITED) Mathematics, and overall grade point averages were secured from school records.

Major Findings and Conclusions.—There was a significantly positive relationship between attitudes as measured by the Inventory and by teachers' ratings ($r = 0.48$); by composite ITED percentile ranks ($r = 0.64$); by mathematics ITED standard scores ($r = .38$); by teachers' grades ($r = 0.39$); by grade point average ($r = 0.23$); and by measures of mental ability ($r = 0.30$).

42. **Ellis, Sarah Fisch.** "A Study of Mathematical Concepts in the Seventh, Eighth, and Ninth Grades at Cahaba Heights Junior High School" (M. Ed., 1962, Birmingham-Southern College, Birmingham, Ala.).

Major Faculty Adviser.—Ray Black.

Problem.—To determine how accurately students could define selected mathematical terms.

Procedure.—Thirty mathematical terms were selected and students were asked, without previous notice, to define each one. Responses were marked on a six-point grade scale. Rank-order listings of the weighted scores of each pupil, together with his mathematics grade for the previous semester, were prepared.

Major Findings and Conclusions.—The test scores indicated a wide range of ability within each grade level. The study showed need for a better understanding of the mathematical terms and the operations involving them. There was not a high correlation between marks given by teachers and the test scores; in fact many students with acceptable marks had very low test scores.

43. **Ericksen, Gerald Lawrence.** "Junior High School Pupils' Attitudes Toward Mathematics as a Predictor of Senior High School Scholastic Achievement" (Ph. D., 1962, University of Minnesota, Minneapolis).

Problem.—To investigate ways of summarizing responses of junior high school pupils to verbal attitude items about mathematics as this information relates to the subsequent high school scholastic record.

Procedure.—Criterion data were obtained by examining the senior high school scholastic records of the 310 11th-graders enrolled in a suburban high school in May 1961. This number constituted all who were left of 520 seventh-grade students of 1956–57 who had taken a verbal attitude test. Their records were studied with particular emphasis on elective courses in mathematics and science. From this information, criteria were developed against which the predictive power of the seventh-grade attitudinal data was tested.

Major Findings and Conclusions.—The centroid factor analysis achieved the most satisfactory group classification results. This scaling technique yielded 82 and 79 percent correct classifications.

44. **Faires, Dano Miller.** "Computation with Decimal Fractions in the Sequence of Number Development" (Ed. D., 1962, Wayne State University, Detroit, Mich.).

Major Faculty Adviser.—Chester A. McCormick.

Problem.—To demonstrate that computation with decimal fractions can precede computation with common fractions in a formal program of arithmetic instruction, with a resulting gain in understanding and achievement.

Procedure.—Eight classes of fifth-graders served as the experimental section, and a like group as the control section. The two groups were equated for age, sex, ability, previous achievement, and socioeconomic status. Teachers were equated for academic preparation and teaching experience.

Prior to any formal computation with common fractions, the experimental sections were introduced to computation with decimal fractions, based on an orderly extension of place value and without reference to common fraction equivalents. The control sections were introduced to computation with decimal fractions in the usual procedure.

Major Findings and Conclusions.—The experimental group attained a computational achievement significantly better than that of the control group. Computation with decimal fractions is more like computation with whole numbers than is computation with common fractions.

45. **Faulk, Charles Joseph.** "The Effect of the Use of a Particular Method of Achievement in Problem Solving in Sixth-Grade Arithmetic" (Ed. D., 1960, Louisiana State University, Baton Rouge).

Major Faculty Adviser.—Thomas R. Landry.

Problem.—To determine the effect of a particular method on problem-solving achievement in sixth-grade arithmetic.

Procedure.—Twenty-two teachers and 74 pairs of students participated in the study for 18 weeks. The experimental groups followed a plan which included suggestions for vocabulary exercises, opportunities for talking through problem situations, diagrams and illustrations of problems, estimating answers, and writing solutions to the problems.

Major Findings and Conclusions.—The methods used with both the experimental and control groups were effective, but the difference in mean gains was not satistically significant.

46. **Faust, Claire Edward.** "A Study of the Relationship Between Attitude and Achievement in Selected Elementary School Subjects" (Ph. D., 1962, State University of Iowa, Iowa City).

Major Faculty Adviser.—Herbert F. Spitzer.

Problem.—To examine the relationship between attitude and achievement in arithmetic, reading, spelling, and language.

Procedure.—To secure data on attitude, a "Subject Preference Inventory" was devised, involving paired comparisons of 11 subjects commonly taught in elementary schools. Achievement was measured by the Iowa Test of Basic Skills. The inventories and tests were administered near the end of the first semester. A random sampling of parents was made by mail. Scores from 2,535 fifth-grade pupils, 149 teachers, 302 parents, 51 fourth-grade pupils, and 47 sixth-grade pupils from 16 school systems in the State of Iowa were used. Means were computed for the attitude scores and for the achievement scores. In each of the four subject areas, correlations were computed between pupil-attitude scores and pupil-achievement scores, teacher-attitude scores and mean class-achievement scores, and parent-attitude scores and pupil-achievement scores.

Major Findings and Conclusions.—(*a*) The correlation between the attitude scores and the achievement scores of all pupils was 0.19 in arithmetic, 0.14 in spelling, 0.06 in reading and 0.001 in language. (*b*) Order of pupil preference for the skill subjects was arithmetic, reading, spelling, and language. Order of achievement, as measured by the grade-equivalent scores, was spelling, reading and language (which were the same), and arithmetic. (*c*) The relationship between teacher attitude and pupil attitude toward school subjects tends to be high. (*d*) The attitude of children toward their school subjects is more like that of their father than of their mother.

47. **Finley, Carmen Joyce.** "Arithmetic Achievement in Mentally Retarded Children: The Effects of Presenting the Problem in Different Contexts" (Ph. D., 1962, Columbia University, New York).

Problem.—To compare the achievement of mentally retarded and normal children when the same basic arithmetic problem is presented in different contexts.

Procedure.—Fifty-four educable retarded children and 54 normal third-grade children were tested using three specially designed instruments:

(1) A concrete test item was mounted on a heavy Bristol board. The problem was written on the board and illustrated by means of coins and small objects fastened to it. (2) A pictorial instrument was similar in size and format to the concrete instrument, but the real coins and objects were replaced by illustrations. The items were stapled together in booklet form, one item per page. (3) A symbolic instrument consisted of a statement of the problem without illustration.

Test (1) was individually administered, and tests (2) and (3) were group-administered.

Major Findings and Conclusions.—(1) Performance on these tests was affected by the context. The concrete test item tended to be more difficult for the retarded subjects than either the pictorial or symbolic test item, although the difference did not reach statistical significance. The pictorial item was significantly easier for normal subjects than either the concrete or the symbolic test item. (2) Retarded children performed significantly better than normal children of the same mental age on the test of computational skills, i.e., the symbolic instrument.

48. **Fitzgerald, William M.** "A Study of Some of the Factors Related to the Learning of Mathematics in Grades Five, Seven, and Nine" (Ph. D., 1962, University of Michigan, Ann Arbor).

Major Faculty Adviser.—Phillip S. Jones.

Problem.—To investigate characteristics of children who are successful in learning modern mathematical ideas, and the degree to which children at different grade levels vary in their ability to learn mathematics.

Procedure.—Units dealing with numeration, negative numbers, and nonmetric geometry were written and taught by the investigator in classes of students from grades 5, 7, and 9. Students from the three grade levels were given the same tests, and the overlap in test results was measured.

Major Findings and Conclusions.—The variability in capacity of students to understand mathematical concepts is far greater than commonly assumed. Where fifth-, seventh-, and ninth-grade students were provided with an opportunity to learn the same mathematical concepts, (*a*) the highest 10 percent of the fifth grade learned an amount greater than that learned by the bottom 10 percent of the ninth grade, (*b*) the top 30 percent of the fifth grade learned more than the bottom 30 percent of the seventh grade, (*c*) the top 30 percent of the seventh grade learned more than the bottom 30 percent of the ninth grade.

49. **Fleming, Walter.** "Comparison Experiment of SMSG 7M and 9M Texts with SMSG 7th and 9th Grade Texts" (1962, Minnesota National Laboratory, St. Paul).

Problem.—To identify the difference in mathematics achievement produced by the different SMSG texts.

Procedure.—Fourteen seventh-grade classes, 18 ninth-grade classes, and 16 teachers, all from 16 Minnesota schools, participated in the experiment. Each of the 16 teachers taught one experimental class with the SMSG "M" text (for the student whose mathematical talent is underdeveloped) and one experimental class with the regular SMSG text for a given grade level.

Essentially the same topics were covered in each of the two experimental classes and the same tests were given to both classes.

Classes were very nearly uniform in size, about 30 students each, and class periods were of equal length. The seventh-grade students were drawn from the upper half of each school's seventh-grade students. The ninth-grade students were drawn from the upper one-third of the ninth-grade students of the school. In each school the students were assigned to the experimental classes in such a way that the two classes were approximately of equivalent ability.

Major Findings and Conclusions.—For each teacher the average score on the SMSG unit tests was higher for students using the M text than for students using the regular text. Average scores on STEP tests showed no consistent difference between students using the M text and students using the regular text.

50. **Ford, Patrick L.** "The Mathematics Included in Programs for the Education of Secondary School Teachers in the Southern Association" (Ph. D., 1961, University of Missouri, Columbia).

Major Faculty Adviser.—Ralph K. Watkins.

Problem.—To determine the extent to which persons preparing to teach secondary school mathematics are provided with experiences necessary to understand and teach the content of the major modern programs in secondary school mathematics.

Procedure.—A questionnaire was used to determine the nature of the courses which made up the undergraduate mathematics program. The content of the textbooks for these courses was analyzed.

Major Findings and Conclusions.—(1) There was a consistency in the courses required of prospective mathematics teachers. (2) Experiences were being provided that were pertinent to both the traditional and experimental programs. (3) Geometry was an area in which the prospective teacher may not be receiving the experiences needed for the type of mathematics he will be expected to teach. (4) Indications were that those currently being prepared to teach mathematics will be unfamiliar with the *types* of secondary school mathematics programs in which they may begin their teaching careers. Critical reviews of the *several* secondary programs were rarely being provided.

51. **Freeman, Robert Sumner.** "A History of Mathematics for the Junior High School Student of Average Ability" (M. Ed., 1962, West Chester State College, West Chester, Pa.).

Major Faculty Adviser.—Frank Milliman.

Problem.—To select elements from the history of mathematics which could be used to increase motivation and understanding by junior high school students of average ability.

Procedure.—A study was made of contemporary textbooks, courses of study, and books on the history of mathematics. Materials believed to be useful were developed under the headings of mathematics as a language, number systems, algorisms, mathematics' helpers, measurement, geometry, algebra, machines, the future.

Major Findings and Conclusions.—If teachers were to incorporate these types of materials into their teaching, they would find them useful in motivating students.

52. **Furman, Walter Laurie.** "Comparison of High School and College Grades in Mathematics" (1962, Spring Hill College, Mobile, Ala.).

Problem.—To determine the relationship between high school and college mathematics grades for a selected group of college students.

Procedure.—The study involved students in the seminary curriculum at St. Charles College in Grand Coteau, La., who study no mathematics in the first 2 years, but enroll in a summer school course in college algebra one summer and in analytic geometry and calculus the next summer. These courses enroll about 15 students each summer. High school mathematics grades were compiled from their transcripts and were compared with the grades received in the college courses. Comparisons were made between the computed averages for the high school mathematics grade marks and the grades in college algebra and in analytic geometry-calculus.

Major Findings and Conclusions.—Grades in the college mathematics courses were approximately in the same range as high school grades despite the 2-year period when no mathematics courses were taken. Thus, for this restricted group of students, high school mathematics grades gave a good indication of the quality of work to be expected in the required college mathematics courses.

53. **Garner, Meridon V.** "A Study of the Educational Backgrounds and Attitudes of Teachers Toward Algebra as Related to the Attitudes and Achievements of Their Anglo-American and Latin-American Pupils in First-Year Algebra Classes of Texas" (Ed. D., 1963, North Texas State University, Denton).

Major Faculty Adviser.—Robert V. Osmon.

Problem.—To determine the relationships among the following variables: (*a*) educational background of teachers, (*b*) attitudes of teachers toward algebra, (*c*) achievement of pupils, (*d*) pupils' attitude, (*e*) Anglo-American pupils, and (*f*) Latin-American pupils.

Procedure.—Forty-five first-year algebra teachers and their 870 Anglo- and 290 Latin-American pupils were selected for the study. Each pupil and teacher was administered an attitude inventory especially designed for the study, at the beginning and at the end of the school year. The Cooperative Algebra Test was also administered at the beginning and at the end of the school year. The hours in college mathematics and in professional education were obtained for each teacher. Data for the two ethnic groups were treated separately and then collectively.

Major Findings and Conclusions.—Anglo-American pupils' beginning attitudes toward algebra, judgments on the practical value of algebra, and competencies in algebra were significantly higher than those of the Latin-American pupils. Anglo-American pupils' end-of-course attitudes toward algebra and judgments on the practical value of algebra are significantly related to their achievements in algebra.

Significant relationships existed between teachers' backgrounds in mathematics and pupil achievements in algebra, and between teachers' attitudes toward algebra and the end-of-course attitudes of pupils toward algebra. No significant relationship existed between teachers' attitudes toward algebra and pupils' achievements in algebra.

54. **Garrison, Nelson.** "The Effectiveness of Programed Materials in a Teaching Machine Used in a Supplement to Normal Class Methods with Elementary Algebra High School Students over Several Ability Levels" (M.A., 1962, University of Louisville, Ky.).

Major Faculty Adviser—J. R. Binford.

Problem.—To determine the effectiveness of programed materials as a supplement to normal class instruction.

Procedure.—Three ability-achievement groups having access to programed materials were compared with a control group that had no such access. One "unit" of approximately 6 weeks of material was covered. An achievement test, constructed by the author and others and having a split-half reliability greater than 0.95, was administered.

Major Findings and Conclusions.—The better students made more use of the programed materials than the poor students, and the more able the student, the greater the gain.

55. **Geddes, Dorothy Clara.** "The Use of Television in Teaching Tenth Year Mathematics" (Ph. D., 1961, New York University, New York).

Problem.—To test the effectiveness of teaching 10th-year mathematics by a combined method of television instruction and instruction with a classroom teacher as contrasted with the traditional method of instruction with a classroom teacher only.

Procedure.—A total of 232 students were involved in 5 public senior high schools in Nassau and Westchester counties, with an experimental and control class in each school. The experimental class viewed three 30-minute telecasts each week and received the remainder of its instruction from the regular classroom teacher. The control class in each school had the same classroom teacher as the experimental class and received all of its instruction from this teacher. The course of study, the total instruction time, and the objectives were the same for both groups. The duration of the study was one academic year.

Major Findings and Conclusions.—The combined method of television instruction and instruction with a classroom teacher was as effective as the traditional method of instruction with a single classroom teacher in fostering interest in mathematics, in developing spatial visualization, in increasing critical thinking ability, and in learning 10th-year mathematics. Pupil and teacher response to the overall evaluation of the television lessons was favorable.

56. **Grabenheimer, Ruth.** "Academic Mathematics in New York City Public Schools Since 1930" (Ph. D., 1961, Teachers College, Columbia University, New York).

Major Faculty Adviser.—Myron F. Rosskopf.

Problem.—To present an analysis of the interactions among the various State and local school personnel with respect to mathematics.

Procedure.—General mathematics including basic concepts from all traditional mathematics courses was added to the curriculum so that all high school students might have the benefit of at least 1 year of high school mathematics. College courses in analytic geometry and calculus, and programing for computers have been introduced to meet the needs of superior students. Track programs have been established for the slow, average, and superior students. Guidance is provided to students in making appropriate course elections.

Major Findings and Conclusions.—Interactions have resulted in the development of a continuing, coordinated program for the learning of mathematics from the beginning of elementary school through college.

57. **Graessle, Rolin A.** "The Determination of the Variables Necessary for the Successful Prediction of Achievement in Plane Geometry Based Upon One Hundred Juniors at Mountain High School, West Orange, New Jersey, 1961–62" (1962, Montclair State College, Upper Montclair, N.J.).

Problem.—To determine an equation for predicting individual achievement in plane geometry.

Procedure.—The null hypothesis was tested, i.e., that the correlation coefficients, both single and multiple, between the predicting variables and the geometry grade were zero.

The variables selected were English I mark, Algebra I mark, verbal IQ score on the California Test of Mental Maturity, and the nonverbal IQ score on the same test. Achievement was measured in terms of the final mark received. The letter marks were transformed into numerical measures of 4, for A, to O, for F. The linear correlation coefficients were calculated between each of the four predicting variables and between the predicting variables and the plane geometry mark. The multiple correlation coefficients were calculated between the predicting variables and plane geometry marks where the predicting variables were considered in combinations of two, three, and four at a time.

Each of the linear and multiple correlation coefficients was subjected to the "F" test to determine whether the hypothesis should be accepted or rejected. As the number of predicting variables was increased, the increase in the coefficients of correlation was tested to see if the increases were statistically significant enough to warrant the use of additional predictors. The regression equation was calculated and based upon these results.

Major Findings and Conclusions.—The highest correlation coefficient based upon the Algebra I marks and verbal IQ scores, 0.685, proved to be statistically significantly larger than the highest correlation coefficient (0.657) based upon only one predicting variable, the Algebra I mark. The regression equation was $Z = -2.703 + 0.896x + 0.023Y$, where X represents the Algebra I mark in numerical form, Y represents the verbal IQ score, and Z represents the predicted plane geometry grade in numerical form.

58. **Gray, Ronald Frederick.** "Effects of an Algebraic (Equation) Approach to Junior High School Mathematics" (Ed. D., 1961, University of California, Berkeley).

Major Faculty Adviser.—T. Bentley Edwards.

Problem.—To determine the effects of teaching seventh-grade mathematics by the algebraic equation approach.

Procedure.—A seventh-grade class was taught the formal solution of equations and their application throughout the course. Achievement was measured by the New York State Junior High School Survey Test in Mathematics.

Major Findings and Conclusions.—The girls achieved significantly above seventh-grade levels and not significantly below eighth-grade levels, in all except computations. The boys did not achieve significantly above seventh-grade levels, but neither were they significantly below. In concepts, the group as a whole was significantly above seventh-grade level. The investigator reported that the attitudes improved for this group.

59. **Guilbault, Brother Alexis Henry.** "The Introduction of Modern Mathematics into the High School Curriculum for the College Preparatory Program" (Ed. D., 1961, Teachers College, Columbia University, New York).

Major Faculty Adviser.—Howard F. Fehr.

Problem.—To establish a set of criteria for introducing new topics into the college-preparatory high school curriculum.

Procedure.—Five criteria were established for the selection of topics for a modern mathematics curriculum. A detailed analysis of two experimental programs was made to illustrate use of the criteria in appraising a curriculum.

Major Findings and Conclusions.—The elementary and junior high school mathematics programs were cited as needing further study and possible revision.

60. **Gumm, Robert O.** "A One-Semester Course of Study in Modern Mathematics for Grade Twelve" (M.S., 1961, University of Kansas, Lawrence).

Major Faculty Adviser.—Gilbert Ulmer.

Problem.—To prepare a 1-semester course in modern mathematics for the 12th grade.

Procedure.—The language of sets was introduced at the outset and was used throughout whenever it served to simplify and clarify. The real number system was developed from an axiomatic approach, starting with the natural number system and proceeding from that to construction of the integers and rational numbers.

Major Findings and Conclusions.—The course that was developed bridges the gap between the traditional mathematics program in high school and a modern college mathematics program.

61. **Hammond, Robert Lee.** "Ability With The Mathematics Principles Governing the Operations of Addition, Multiplication, Subtraction, and Division" (Ed.D., 1962, University of Southern California, Los Angeles).

Major Faculty Adviser.—Robert A. Naslund.

Problem.—To determine the relationship between mental ability and understanding of principles governing addition, subtraction, multiplication, and division.

Procedure.—A "Test of Mathematical Operations" was devised for use in the study. This test and standardized tests of arithmetic achievement, mental ability, and algebra aptitude were administered to 300 seventh-grade students in public junior high school.

The relationship between the mathematical principles governing the operations and each of the standardized tests was analyzed by multiple-correlation techniques. The relationship of the factors of mathematical ability assessed by the Test of Mathematical Operations to each of the variables was explored by factor analysis.

Major Findings and Conclusions.—A significant relationship exists between ability as described by the Test of Mathematical Operations, and (*a*) mental ability as indicated by language and nonlanguage IQ determined from the California Short Form Test of Mental Maturity, (*b*) arithmetic ability as indicated by scores on the arithmetic reasoning and fundamental sections of the California Achievement Test, Grades 7–8–9, Form X, and (*c*) algebra aptitude as measured by the Survey Test of Algebraic Aptitude.

62. HANCOCK, JOHN DAVID. "The Evaluation of the Secondary Mathematics Curriculum: A Critique" (Ed. D., 1961, Stanford University, Palo Alto, Calif.).

Problem.—To provide a transition from earlier recommended modifications of the secondary mathematics curriculum to the ones recommended currently.

Procedure.—The distinguishing characteristics of eight different reports, starting with that of the Committee of Ten, and of three current projects (University of Illinois Committee on School Mathematics, School Mathematics Study Group, and Commission of Mathematics of the College Entrance Examination Board) were identified.

Major Findings and Conclusions.—(1) Attention to aims has depended upon the current need to justify retention of mathematics in the secondary curriculum. When society saw no pressing need for the study of mathematics, emphasis was placed upon the utilitarian aims of instruction; during periods of economic depression, cultural aims were emphasized; when need for mathematics was clearly evident there was a tendency to assume that whatever mathematics could be taught was justified. (2) Methods have received comparatively little attention by national committees or current projects. (3) Algebra in some form or other has been recommended for the ninth grade by all committees reporting throughout the past seven decades. Demonstrative geometry has been recommended for grade 10. Currently, proposals renew the call for integration of related fields, and they place greater emphasis on mathematical structure and logical development.

63. HANNARKIN, PANAS. "A Proposed Mathematics Program for the Comprehensive Secondary School in Thailand" (Ed. D., 1962, Indiana University, Bloomington).

Major Faculty Adviser.—Philip Peak.

Problem.—To determine the characteristics of a desirable mathematics program in the United States and to use them as a basis for a program in Thailand.

Procedure.—On the basis of recommendations from journals, curriculum guides, and similar publications, the investigator set up criteria for a good mathematics program in the United States.

Major Findings and Conclusions.—A good mathematics program should (a) be available to all students, (b) be contemporary in content capable of meeting present needs, (c) have continuity of content that is integrated within the field of mathematics, and (d) have provisions for individual student differences.

For the secondary schools in Thailand (1) statistics should be made available to the nonacademic students in grades 9 and 10, (2) solid geometry, coordinate geometry, and inferential statistics should be added for the academic track, and (3) the program should be modernized by introducing scientific notation, the binary system, complex numbers, vectors, sets, groups, and fields.

64. **Hansen, F. Lloyd.** "Correspondence Course for the Gifted Students in Mathematics" (1961, Minnesota National Laboratory, St. Paul).

Problem.—To determine whether high-ability students could master SMSG courses by independent study.

Procedure.—The content of the correspondence courses was based on the SMSG 9th- and 10th-grade sample texts. The courses were made available in Iowa, Wisconsin, Minnesota, and the Dakotas in 1959–60 to students in the top 0.5 percent according to mathematics ability and achievement, and in the same States in 1960–61 to students in the top 5 percent.

Each student proceeded at his own rate but was encouraged to follow a minimum target schedule. A certificate was awarded for successful completion of the course.

Major Findings and Conclusions.—A completion rate of about 20 percent was obtained for the algebra (9th-grade) course and of about 25 percent for the geometry (10th-grade) course. Recommendations included (*a*) greater supervision and encouragement of the student, (*b*) regular high school credit for the course, or reduction of regular academic courses, and (*c*) the preparation of similar programs for senior students.

65. **Hansen, Viggo Peter.**—"Elementary Algebra Achievement as Related to Class Length and Teaching Method" (Ph. D., 1962, University of Minnesota, Minneapolis).

Major Faculty Adviser.—Donovan A. Johnson.

Problem.—To investigate differentials in the learning of ninth-grade algebra resulting from (1) lengthening the class period from 55 minutes to 110 minutes but meeting on alternate schooldays and (2) varying the teaching methods used in the 110-minute class periods.

Procedure.—Seventy-four ninth-grade students were randomly assigned to one of three treatments. In treatment A, students met in 110-minute class periods on alternate schooldays. Activities included extended class discussions, use of a mathematics laboratory, library reading and research, oral reports to the class, and increased use of instructional aids. Treatment C, applied to the control class, was intended to be typical of that received by an elementary algebra class. The class met daily for 55 minutes. Treatment B was likewise intended to be typical of that received by an elementary algebra class. The class met in 110-minute class periods on alternate schooldays. All classes used the experimental SMSG text *First Course in Algebra.* The same teacher taught all three classes.

Major Findings and Conclusions.—Students in the 110-minute class periods did as well in achievement as did students in the daily 55-minute classes. A significant difference favored the 110-minute class that used a variety of classroom and laboratory activities (Treatment A). Student attitude toward the lengthened class period was favorable.

66. **Harshman, Hardwick W.** "Manipulative Materials and Arithmetic Achievement in Grade One" (Ph. D., 1961, University of Michigan, Ann Arbor).*

Major Faculty Adviser.—Joseph N. Payne.

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*This dissertation reports most of a study done jointly by Hardwick W. Harshman, David W. Wells, and Joseph N. Payne.

Problem.—To investigate the relative effectiveness of selected manipulative materials for teaching arithmetic in the first grade.

Procedure.—Three groups of first-grade students used three different sets of manipulative materials for a full school year. One group used a commercial set known as the Numberaid, Program A. A second group used a set of inexpensive materials, Program B. A third group used materials selected by the teacher as needed, Program C. Achievement tests and an attitude survey were given to the pupils. Tests results were analyzed using the analysis of variance technique. The total number of pupils was 654.

Major Findings and Conclusions.—No significant differences in arithmetic computation, arithmetic reasoning, and total arithmetic achievement were found among the programs when the mean scores of the classes were used or when individual scores for IQ subgroups 125 and above and 99 and below were [illegible] sing individual scores, there were no significant differences obtained [illegible]tude for any of the groups. Using the mean scores of individuals, there were significant differences at the 0.01 level in favor of Program C.

67. **Heckman, Maurice A.** "The Relative Merits of Two Methodologies for Teaching Verbal Arithmetic Problems to Undergraduate Elementary Education Majors" (Ed. D., 1962, Indiana University, Bloomington).

Major Faculty Adviser.—Ronald C. Welch.

Problem.—To determine the relative merits of two methodologies for teaching verbal arithmetic problems to undergraduate elementary-education majors.

Procedure.—The study was restricted to 47 elementary-education majors, all of whom were undergraduate juniors enrolled in the course *The Teaching of Arithmetic in the Elementary School* during the spring semester, 1962. Twenty-four of the subjects, comprising one section of the class, were taught by an inductive-deductive methodology and were identified as the experimental group. The remaining 23 subjects, comprising the other section of the class, were taught by a deductive methodology and were identified as the control group. Daily lesson plans constructed by the investigator and tape recordings of the classroom procedures supplied basic information for the production of the descriptive materials in the study. The *Sequential Tests of Educational Progress* (Forms 1A and 1B) were selected as the instruments for measuring problem-solving achievement. Data were analyzed statistically. Tests of chi-square were used to determine the difference between groups on responses made to the written assignment. To determine the difference between groups on problem-solving achievement, t-tests were used. *A priori* evidence and authoritative judgment were used to analyze the remaining data.

Major Findings and Conclusions.—(1) There was no significant difference between the experimental and control groups on verbal arithmetic problem-solving achievement at the end of the semester. (2) Significant differences between the experimental and control groups in individual methods of problem-solving and in individual methods of teaching verbal arithmetic problem-solving favored the use of meaningful developmental procedures.

68. **Heddens, James William.** "A Comparison of Three Methods of Estimating Quotients" (Ed. D., 1960, Colorado State College, Greeley).

Problem.—To determine which of three methods of estimating quotients

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was the best to teach to children. The three methods were the "increase-by-one" method, the "apparent" method, and the "round-off" method.

Procedure.—The problem was considered from three aspects; the computational process, the skill of children in solving numerous problems, and the speed with which solutions could be given. A computational analysis was made to determine which of the three methods of two-digit division would give the true quotient on the first estimate the greatest percent of the time. The study included each of 81 divisors and 44,550 dividends.

An experiment in which 231 fifth-grade children from Des Moines, Iowa, estimated quotients for two-digit division problems was conducted in both departmental and self-contained classes. A time study was used to determine if students could manipulate faster by one of the methods. Each of the teachers participating in the study were instructed in the use of the three methods.

Major Findings and Conclusions.—The computational analysis supported the conclusion that the round-off method gave the true quotient a greater percent of the time. The real difference between the methods was with the "division demons" and the harder division problems.

The experimental anaylsis indicated that all three methods were equally effective in improving the children's abilities to estimate quotients. In general, the more time spent on instruction and practice with a method was accompanied by less time on the part of the children in estimating quotients.

69. **Heimer, Ralph T.** "The Preparation of a Program in Contemporary Algebra and a Study of its Effectiveness for Group Instruction Under Paced Conditions" (Ed. D., 1962, The Pennsylvania State University, University Park).

Major Faculty Adviser.—Franklin A. Miller.

Problem.—(1) To develop a programed course in modern elementary algebra and obtain a measure of its effectiveness, (2) to compare the effectiveness of the programed material presented via (*a*) book form for self-instruction, (*b*) teaching machines for self-instruction, and (*c*) filmstrip projection under paced conditions.

Procedure.—A group of 112 Penn State students enrolled in college algebra made up the study population. The students in the programed book and teaching machine groups proceeded through the programed material on a self-pacing basis; the filmstrip group proceeded through the identical programed material, with their learning pace being externally governed; and the conventional class received conventional instruction on the same subject matter covered by the program.

The 15 programed units were completed by each treatment group, one unit per class period; a test was administered upon the completion of each unit and a final examination at the termination of the treatment period. A study guide containing review material and exercises for outside assignment was distributed to each student at the completion of each class period.

Major Findings and Conclusions.—The overall performance of the program groups was about 75 percent on the achievement measures used. With respect to total unit-test scores, a significant difference favoring the program treatment was found between means when the combined program treatments were compared against the conventional treatment. A similar comparison on final examination scores revealed no significant treatment effects.

Neither of the analysis of variance tests based on the final examination scores and on the summed unit scores revealed any significant difference among the experimental treatments of the three program groups.

70. **HEUER, HARLAN A.** "Some Suggestions for Fusing Plane and Solid Geometry in a Single Course" (M.S., 1962, University of Kansas, Lawrence).

Major Faculty Adviser.—Gilbert Ulmer.

Problem.—To set forth a method whereby the basic properties of a solid geometry course could be combined with the important aspects of plane geometry.

Procedure.—The proposed sequence of topics do not follow that of any particular textbook in geometry. The attempt was made to relate the theorems of plane and solid geometry in a manner that could be adapted to practically any geometry textbook.

Major Findings and Conclusions.—A tryout of the proposal led to the opinion that the materials were teachable and student achievement was at least as high as that expected of a conventional class.

71. **HIGHT, DONALD WAYNE.** "A Study of the Limit Concept in the SMSG Revised Sample Textbooks" (Ed. D., 1961, Oklahoma State University, Stillwater).

Major Faculty Adviser.—James H. Zant.

Problem.—To embed a rigorous treatment of the limit concept into the SMSG revised sample textbooks.

Procedure.—An analysis of the textbooks determined the discussions that involved limits. Such discussions were restated in more exact mathematical terms to yield definitions and theorems. The theorems for which the texts suggested a proof were proved by arguments using text materials or by selections from other texts. Invalid arguments were identified and tacit assumptions were explicitly stated.

Major Findings and Conclusions.—A reordering of topics was found to be necessary to embed a rigorous treatment of the limit concept.

72. **HOAGLAND, MATHIAS ADEN.** "An Appraisal of Opinions of Eighth-Grade Students Toward Ability Grouping in Mathematics" (M.S., 1961, University of Utah, Salt Lake City).

Major Faculty Adviser.—L. Edwin Hirschi.

Problem.—To determine the opinions of eighth-grade students toward ability grouping.

Procedure.—The opinions of 246 eighth-grade students at Central Junior High School in Kalispell, Mont., were secured by questionnaire.

Major Findings and Conclusions.—(*a*) A majority of the students favored ability grouping. (*b*) Students believed that the top and low groups benefited most and that the average group benefited least. (*c*) Little damage was done to friendship patterns. (*d*) Practically all students were aware that they had been grouped, and a majority knew in which group they had been placed. (*e*) Four-fifths of the students thought ability grouping was more democratic than nonability grouping.

73. **HODGES, JOHN RAYMOND.** "A Study of the Ability of a Group of Eighth-Grade Students to Learn and Use Certain Mathematical Concepts" (Ph. D., 1963, George Peabody College for Teachers, Nashville, Tenn.).

Problem.—To test the hypothesis that certain eighth-grade students can learn important basic mathematical concepts regardless of prior mathematical achievement.

Procedure.—Participants in the study were 63 eighth-grade students in a parochial school located in a new, all-white, residential section of a large Southern city. The eighth grade was divided into two groups: "average" and "superior." The criteria for the separation were the students' scores on a standard arithmetic achievement test and the teacher's evaluation of the student's scholastic ability. Each group was further divided into two matched subgroups on the basis of student arithmetic scores. One subgroup served as the experimental group and the other as the control.

Each experimental group was taught the same experimental material, both in content and order of presentation for a period of 20 contact days. The topics covered were sets, partitions, variables, subscripts, definitions, postulates, identity and inverse elements, operations, relations, isomorphisms, and a postulational development of the rational number system.

The control groups were taught taxation, insurance, banking and interest, promissory notes, and the metric system by their regular teachers for a period of 15 contact days. During the following 4 days, the experimenter taught the control groups the traditional development of the rational number system as presented in the student's text. Data were subjected to standard statistical tests using the treatment-by-levels design.

Major Findings and Conclusions.—Eighth-grade students can learn the concepts and terminology taught regardless of prior mathematical achievement. Both methods of teaching rational numbers are equally effective. However, the experimental method was better for the "average" group, whereas the traditional method was better for the "superior" group. The investigator concluded that emphasis on concept meaning should be combined with drill in teaching directed numbers.

74. HOLMES, EMMA ELIZABETH. "An Investigation of Cardinal and Ordinal Number Concepts of Children from Three to Six Years of Age" (Ph. D., 1961, State University of Iowa, Iowa City).

Major Faculty Adviser.—Herbert F. Spitzer.

Problem.—To test hypotheses about the development of cardinal and ordinal number concepts of young children.

Procedure.—A number concepts test of 37 items was devised. The items dealt with equality, cardinal correspondence, ordinal correspondence, cardinal and ordinal number interrelated, cardinal and ordinal number coordinated, correspondence, seriation and correspondence, locating ordinal number, rational counting, and rote counting. It was administered individually to 144 subjects ranging in age from 3 years, no months, to 6 years, 4 months.

Major Findings and Conclusions.—(1) The results implied that concepts of cardinal and ordinal number do not develop synchronically. (2) Kindergarten children possess an understanding of number names in serial order before forming mature concepts of cardinal correspondence and ordinal correspondence. (3) At the kindergarten age, cardinal concepts of numbers were shown to be more adequate for the solution of problems involving cardinal number than ordinal concepts of number were for the solution of problems of comparable difficulty but involving ordinal number. (4) Some concept of quantity, though crude and unrefined, had been formed by the subjects prior to entrance into kindergarten.

75. **Houston, William Robert, Jr.** "Selected Methods of Inservice Education and the Mathematics Achievement and Interest of Elementary School Pupils" (Ed. D., 1961, University of Texas, Austin).

Major Faculty Adviser.—M. Vere DeVault.

Problem.—To evaluate the relative effectiveness, in inservice education for elementary school teachers of mathematics, of (1) television, (2) face-to-face lecture-discussion, (3) television supplemented by consultant services, (4) and face-to-face lecture-discussion supplemented by consultant services.

Procedure.—Ninety-two fourth-, fifth-, and sixth-grade classes were the population of the study. Teachers of these 92 classes participated in an inservice education program. Half of the teachers received television instruction and the other half participated in face-to-face lecture-discussions. The same instructor provided the instruction in both methods. Consultant services were provided to half the teachers in the television group and to half of those in the lecture-discussion group. Pupil change was measured by pre- and post-tests.

Major Findings and Conclusions.—(1) Both television and face-to-face lecture-discussion were equally effective media of inservice education, as evaluated by change in pupil achievement and interest in mathematics. (2) The presence of a consultant did increase the pupils' interest in mathematics but made no apparent difference in their achievement. (3) There were no differences in relative effectiveness of the four methods of inservice education.

76. **Huber, Sister Mary Lawrence.** "Developments in Mathematics Education at the Junior High School Level Since the Turn of the Century" (Ed. D., 1926, University of Buffalo, N.Y.).

Major Faculty Adviser.—A. L. Kaiser.

Problem.—To survey the history of mathematics education from 1890 to 1962.

Procedure.—The study is an historical survey of the developments in mathematics education from 1890 to 1950 and an investigation of recent and current literature, experimental programs, and studies from 1950 to 1961. Proposals for mathematics reform before 1900, from 1900 to 1925, from 1925 to 1950, and "Current proposals" are discussed and summarized separately.

Major Findings and Conclusions.—Efforts to reform mathematics education began as early as 1890 when it was recommended that new concepts be introduced at the seventh and eighth grades. The same criticism is being made against the traditional programs for these grades. A number of the previous recommendations are being incorporated into current experimental mathematics programs.

Inadequate preparation of teachers was among the reasons cited by the investigator for ineffective implementation of the earlier recommendations.

77. **Ikeda, Hitoshi.** "The Application of the Meaning Theory to the Teaching of Arithmetic in Selected Third-Grade Classes of Indian Children in the Public Schools of New Mexico" (Ed. D., 1961, University of New Mexico, Albuquerque).

Major Faculty Adviser.—Miles V. Zintz.

Problem.—To develop a program of meaningful arithmetic instruction in selected third-grade classrooms to halt the progressive retardation characteristic of Indian children.

Procedure.—The subjects of the study included all of the third-grade Indian pupils enrolled in 13 classrooms and 28 beginning fourth-grade Indian children in 7 schools participating in the Indian Research Study. The sample was restricted to pupils present on the various testing dates. The New York Test of Arithmetical Meanings, Level Two, was administered in the fall and again in the spring. Special emphasis was placed on providing arithmetic instruction at the pupil's level of achievement. Pupils were subgrouped within classes.

Major Findings and Conclusions.—All groups achieved significant gains during the year. The combined Indian group at the end of the third grade achieved significantly greater than a group of 28 unselected fourth-grade Indian children tested at the beginning of the year. The degree of retardation of the Indian children did not increase during the year.

Pupil and teacher reactions to the institutional program were favorable.

78. **Ingrelli, Anthony. V.** "Method Preferences of Sixth-Graders in Three Milwaukee Schools for the Division of One and Two Place Decimals" (1961, University of Wisconsin, Milwaukee).

Problem.—To determine the method preferences of sixth-graders in three Milwaukee schools for the division of one- and two-place decimals.

Procedure.—Three sixth-grade groups, 79 pupils in all, participated in this study. One group came from homes where parents were college or university graduates, one from homes in a middle-class residential area, and one from homes in a congested area with a transient population where parents generally were semiskilled or unskilled workers.

In method A, a caret sign was used to show that the divisor and dividend were multiplied by a power of 10. In method B, the divisor was rewritten as a whole number after being multipled by a power of 10. In method C, the quotient was determined by subtraction of the number of decimal places in the divisor from the number in the dividend; zeros were annexed to the dividend when the latter had fewer decimal places than the divisor.

One method was introduced at a time, and 3 class periods of 40 minutes each were given to each method before the next was introduced. The first group began with method A, the second with method B, and the third with method C. Discussion, demonstration, practice tests, and individual assistance were all part of the instruction in each method. After the students had been familiarized with the three methods, a 10-problem test using 1, 2, and 3 digit numbers with no remainders was administered. Students checked their preference of method on the final test.

Major Findings and Conclusions.—Method A was chosen by 53 percent of the pupils, method B by 6 percent and method C by 32 percent, with 9 percent undecided. There was very little difference in choice according to sex.

79. **Jamison, King Wells, Jr.** "The Effectiveness of a Variable Base Abacus in Teaching Counting in Numeration Systems Other Than Base Ten" (Ph. D., 1962, George Peabody College, Nashville, Tenn.).

Major Faculty Adviser.—Susan B. Riley.

Problem.—To determine the effectiveness of a variable-base abacus in teaching counting in numeration systems other than base 10.

Procedure.—Instruction in counting in other numeration systems was provided. Treatment A used a demonstrator-sized variable-base abacus; treatment B used the demonstrator in addition to a small variable-base abacus for each pupil; and treatment C used no aids other than blackboard and chalk. Each treatment group received a pretest, 5 days of instruction in counting in numeration systems other than base 10, and a post test. Achievement scores were subjected to a simple randomized analysis of variance, which was followed by an analysis of covariance with Lorge-Thorndike IQ measures used as a concomitant variable.

The experiment was conducted with 94 students in the seventh-grade classes of three schools.

Major Findings and Conclusions.—No significant difference among the groups was found.

80. **Jarvis, Oscar Thad.** "A Statistical Analysis of the Relationship of Varying Time Allotments to Pupil Achievement in Reading, Arithmetic, and Language of the Intermediate Elementary School Grades in the Texas Gulf Coast Area" (Ed. D., 1962, University of Houston, Houston, Tex.).

Major Faculty Adviser.—Wallace H. Strovell.

Problem.—To determine the relationship between varying class period lengths and pupil achievement in reading, arithmetic, and language of the intermediate elementary-school grades in the Texas Gulf Coast area.

Procedure.—An analysis was made of the achievement level of 329 pupils studying reading for an average of 60–78 minutes daily, arithmetic 55–60 minutes daily, and language 40–50 minutes daily. These results were compared with the achievement of 384 students studying in class periods in the corresponding subjects of 40–50 minutes, 35–45 minutes, and 25–30 minutes, respectively. Achievement test results for pupils with IQ's of 95 or less for the two varying time groups were compared, as were those for pupils with IQ's of 115 or more.

The California Short Form Test of Mental Maturity was used to determine that the two groups did not differ significantly in ability. The California Achievement Test Complete Battery was administered, with the scores used to derive a mean grade-placement equivalent for the maximum and minimum time allotment groups in reading, arithmetic, and language. Differences in the mean grade-placement equivalents were subjected to the t-test to determine whether they were significant.

Major Findings and Conclusions.—In the classes having longer periods, achievement was significantly higher for the pupils as a whole, and for those at both the low- and high-IQ levels in arithmetic reasoning and arithmetic fundamentals. These differences were significant at the 0.05 level of confidence. The longer period classes also favored achievement in language mechanics, with the differences being significant at the 0.01 level of confidence.

81. **Johnson, Donovan.** "A Study of the Relative Effectiveness of Drill Material as a Supplement for SMSG Courses" (1962, Minnesota National Laboratory, St. Paul).

Problem.—To determine the contribution of supplementary drill to mathematics achievement in classes using SMSG texts.

Procedure.—The study involved grades 7, 8, and 9, in 12 Minnesota schools. At each of these three grade levels, each of four teachers taught one experimental and one control class. All classes used SMSG texts for the appropriate grade. All 12 teachers had had previous experience in teaching SMSG material at the same grade level as the one to which they were assigned in the experiment. The experimental classes used drill problems composed by the participating teachers in addition to the SMSG material. Control classes studied the SMSG text exclusively. The time corresponding to that used by the drill activities of the experimental classes was used for more intensive work on the problems provided in the SMSG text. Teachers were requested to hold constant in both classes other factors such as time, testing, motivation, and instructional technique.

Major Findings and Conclusions.—The supplemental drill appeared neither more nor less effective than no drill in promoting mathematics achievement.

82. KALIN, ROBERT. Development and Evaluation of a Programed Text in an Advanced Mathematical Topic for Intellectually Superior Fifth- and Sixth-Grade Pupils" (Ph. D., 1961, Florida State University, Tallahassee).

Major Faculty Adviser.—Eugene D. Nichols.

Problem.—To determine if programed instruction could enable intellectually superior fifth- and sixth-grade pupils to learn important mathematics not usually taught below the secondary school level.

Procedure.—A programed text for a 2-week unit in equations and inequalities in terms of sets and sentences was developed and pretested. It was evaluated with 95 intellectually superior pupils who were randomly assigned to 5 experimental and 5 control groups. Each experimental subject studied the programed text independently; each control group was taught for ten 40-minute periods by a regular elementary school teacher using conventional techniques. A 44-item criterion test was developed to measure the results.

Major Findings and Conclusions.—Intellectually superior fifth- and sixth-grade pupils apparently can learn advanced mathematics from a programed text, and in less time. The technique is recommended for schools lacking teachers, texts, and pedagogical means of otherwise providing such instruction.

83. KAPRELIAN, GEORGE.—"An Exploratory Study of the Sensitivity of Prospective and Inservice Elementary Teachers to Possibilities for Arithmetic Teaching Situations in Certain School Activities" (Ph. D., 1962, Ohio State University, Columbus).

Problem.—To determine whether the lack of sensitivity to possibilities of arithmetic teaching situations on the part of prospective and inservice elementary teachers was an important reason why children have difficulty in learning arithmetic.

Procedure.—The experimental population, consisted of a random sample of 198 subjects selected from (1) undergraduate elementary-education classes at the universities of Ohio State, Marquette, and Wisconsin at Milwaukee: (2) graduate classes in elementary education at Ohio State, and (3) inservice elementary teachers in the Milwaukee public schools. Data were obtained by the use of questionnaires and responses to a group of seven drawings illustrating possible arithmetic teaching situations.

Major Findings and Conclusions.—(1) A significant relationship existed between subjects' sensitivity levels and their own achievement marks in arithmetic as elementary school pupils. Subjects who preferred to teach in the lower elementary grades displayed higher sensitivity levels than subjects who wished to teach in the intermediate or upper elementary grades.

84. **Kelly, Theresa Louise Sabellico.** "An Evaluation of Textbook and Real-Life Problems in Arithmetic" (Ph. D., 1962, Fordham University, New York).

Major Faculty Adviser.—Marion U. Blanchard.

Problem.—To compare real-life and textbook arithmetic problems.

Procedure.—Fifth-grade children, 191 rural and 205 urban, submitted 1,069 real-life problems. Eight fifth-grade textbooks were used to compile 5,157 textbook problems. The 310 most frequently occurring real-life and 1,156 most common textbook problems were analyzed to determine arithmetical processes and skills. A test of the 10 most common real-life and the 10 most common textbook problems was administered to 206 rural and 224 urban sixth-grade students.

Major Findings and Conclusions.—(1) About three-fourths of real-life problems involved money and about one-fourth concerned whole numbers. (2) More than one-third of the textbook problems involved money, one-fourth concerned whole numbers, and less than one-fifth required fractions. (3) Sixth-graders successfully solved 79 percent of the real-life and 64 percent of the textbook problems. (4) Addition and subtraction are most often required in real life; multiplication and division are presented more frequently in textbooks.

85. **Kennedy, Joseph W.** "The Development of a Test of Skill in Solving Mathematics Teaching Problems" (Ed. D., 1963, Indiana University, Bloomington).

Major Faculty Adviser.—Philip Peak.

Problem.—To develop a test to measure skill in solving teaching problems that occur in teacher-pupil discussions in secondary mathematics.

Procedure.—The proceedings of ninth-grade algebra classes were tape recorded, and simplified teaching situations were derived from the recordings. A test covering 17 problems thus identified was administered 311 times to 6 groups of persons with varied training and experience in teaching mathematics. Subjects were undergraduate elementary-education majors, teachers experienced in fields other than mathematics, preparatory mathematics teachers who had not taken the methods course, preparatory mathematics teachers who had completed the methods course but not student teaching, preparatory mathematics students who had completed both the methods course and student teaching, and experienced mathematics teachers. Specialists in mathematics education assisted in devising a scoring scheme for rating responses on a 4-point scale.

Major Findings and Conclusions.—The mean scores of the six groups had a rank order from lowest to highest identical to the sequence in which they are listed above. An overall analysis of variance for the six groups showed differences among the group means significant at the 1 percent level. The test was found not to be reliable for any single group, but had an estimated reliability coefficient of 0.90 for the total group.

86. **Koehler, Fulton.** "Evaluation of SMSG Text for Grade Four 1961–1962" (1962, Minnesota National Laboratory, St. Paul).

Problem.—To evaluate the SMSG text for grade four.

Procedure.—Ten pairs of fourth-grade classes in the vicinity of Minapolis and St. Paul were selected. The 10 experimental classes used the SMSG fourth-grade texts, while the control classes used conventional texts. The STEP 4A test was administered to all 20 classes in September and again in the following May. The DAT test was administered in February.

Major Findings and Conclusions.—There was no significant difference in the progress of the two groups in mastering traditional work. The experimental group spent considerable time on sets and geometry, which was not reflected in their performance on the STEP 4A tests.

87. KRAFT, CHARLES H. "Evaluation of SMSG Grades 7–12." (1962, Minnesota National Laboratory, St. Paul).

Problem.—To evaluate the mathematics achievements of students using SMSG materials.

Procedure.—Ninety-two classes participated in tryouts of the SMSG materials in grades 7–12. The students were tested during the fall with the SCAT (or DAT) and STEP mathematics tests for their grade. They were retested with a different form of STEP mathematics test in the last week of the following May.

Major Findings and Conclusions.—The students in this evaluation study were generally high in both pretest ability and achievement. They were equally high in post-test achievement. This was in agreement with previous evaluation studies in which it was concluded that, on standard achievement tests, SMSG students do as well as or better than students do, nationwide.

88. KRICH, PERCY. "An Experiment to Compare Two Methods of Teaching Division of Fractions" (Ed. D., 1963, University of California, Los Angeles).

Major Faculty Adviser.—Wilbur H. Dutton.

Problem.—To determine which of two methods of teaching division of fractions by fractions would produce more effective learning: (1) the "meaningful" method, which provides an opportunity for the child to understand the arithmetical processes involved in division of fractions and (2) the "mechanical" method, which provides the child with the rule to apply in dividing and which presents him with material for drill.

Procedure.—Eight elementary schools were paired in such a way as to assure that equivalent socioeconomic areas were represented in each group. From each pair one class was selected and assigned at random to the control group, while the other class was assigned to the experimental group. These two groups were also matched as closely as possible for IQ.

The study used 144 children, equally divided between experimental and control groups. Three tests were administered: a pretest, a post-test, and a delayed test given 2 months after the post-test.

Self-tutoring materials were used. Each child was provided with his own packet of teaching materials, which included instructions for learning the process of dividing a fraction by a fraction.

Major Findings and Conclusions.—No significant difference was found in the immediate learning achieved by either group at any IQ level when tested a day after the program was completed. Testing after a 2-month interval showed that retention by the group taught by the meaningful method increased as IQ increased. This was not true with the group taught by the mechanical method.

89. **Krulik, Stephen.** "The Use of Concepts in Mathematics, New in Teaching the Slow Learner" (Ed. D., 1961, Teachers College, Columbia University, New York).

Major Faculty Adviser.—Myron F. Rosskopf.

Problem.—To explore the possibility of teaching mathematics to slow-learning children through the use of topics not usually included in their curriculum.

Procedure.—An IQ of 70–90, a reading and arithmetic retardation of 2–4 years on standardized tests, and general agreement by the pupil's previous term teachers that he was a slow learner were the criteria used for selecting 9th- and 10th-grade pupils for special classes. Lessons on elementary statistical concepts and on coordinate geometry were tape recorded as they were being taught to the special classes. The tapes were analyzed.

Major Findings and Conclusions.—Mathematics can be learned and retained by the slow learner if it is made meaningful to him and is appreciated by him.

90. **Lane, Bennie Ray.** "An Experiment with Programed Instruction as a Supplement to Teaching College Mathematics by Closed-Circuit Television" (Ph. D., 1962, George Peabody College for Teachers, Nashville, Tenn.).

Major Faculty Adviser.—F. L. Wren.

Problem.—To compare the effectiveness of three methods of supplementing a lecture on college mathematics, presented via closed-circuit television.

Procedure.—All students who were enrolled in "Fundamental Principles of Mathematics" at George Peabody College during the spring quarter of 1962, were assigned at random to one of three treatment groups. Each group viewed the same televised lecture in a separate classroom during the first half of each class period. During the second half of the period each group received instruction based on assigned homework problems, but no new material was presented.

To eliminate teacher differences, the experimenter was responsible for all three supplementary methods. To insure a uniform presentation of material, the assigned homework problems were selected prior to the experiment and a complete set of solutions was prepared. These notes were used in the presentation of each of the three experimental methods.

Group I viewed a kinescope film of the solutions of homework exercises. These films were prepared in advance and presented via television each day. The students were instructed to compare their homework with the television explanation to verify their solutions or to obtain necessary assistance. Some review topics were discussed.

Group II participated in a classroom help session in which the experimenter answered questions pertaining to the assigned exercises.

Group III studied a program booklet prepared by the experimenter and based on the assigned exercises.

After 12 class meetings of experimental instruction, the students were given an achievement test which had been constructed for this study. Each student reported an estimate of his out-of-class time during the experiment and also made comments about the classroom procedure.

The experiment was based on a simple-randomized design with three treatment groups. The achievement test scores served as criterion measures for the analysis of covariance. Scores on the Davis Test of Functional Competence in Mathematics and on the verbal Battery of the Lorge-Thorndike Intelligence Test were used.

Major Findings and Conclusions.—(1) The programed material provided a more effective supplement to televised instruction than did either of the other two methods. (2) The classroom-discussion method and the televised-problem-session method appeared to be equally effective. (3) The experiment provided validation of the programed booklet as a method of instruction for the material which it covered. (4) The average out-of-class study time for the group with the programed booklet was about one-half of the mean time for the other two groups. (5) Student attitude toward the televised supplement was generally negative. (6) Many students enjoyed the use of the programed booklet. (7) Many students liked the classroom help session as a supplement to televised instruction, but some thought that more time was needed in the classroom.

91. **Lang, Robert Wilmer.** "A study of an Accelerated Mathematics Program" (Ed. D., 1962, Wayne State University, Detroit).

Major Faculty Adviser.—T. D. Rice.

Problem.—To ascertain the status of an accelerated mathematics program (AMP) after 3 years of operation.

Procedure.—Questionnaire and opinionnaire surveys were made of staff, students, and their parents.

Major Findings and Conclusions.—The accelerated mathematics program was heavily endorsed by students who were in the program, their parents, the teachers of those classes, and the administrators. The statistical evidence seemed to show that the students in the AMP learned mathematics as well as or better than their counterparts in regular mathematics classes. Persistent problems occurred in the identification of students for the AMP, the attrition rate (about 40 percent), policies on administration of the AMP, and the nebulous but ever present prestige factor.

92. **Larson, Joe Jacob.** "Creativity in Mathematics" (M.S., 1961, University of Utah, Salt Lake City).

Major Faculty Adviser.—L. Edwin Hirschi.

Problem.—To find ways in which mathematics teachers can become more effective in keeping alive the inherent creative abilities of students.

Procedure.—A survey of selected literature revealed characteristics of creativeness which should be nurtured. Strategies to aid in planning lessons for creative teaching were described.

Major Findings and Conclusions.—Creative teaching is complex and difficult. Discovery learning includes exciting classroom activity, and may necessitate a reevaluation of the characteristics of a desirable learning situation.

93. **Lawson, Fred Russell.** "A Comparative Study of the Achievement of Eighth and Ninth Grade Students in Beginning Algebra" (Ed. D., 1961, University of Oklahoma, Norman).

Major Faculty Adviser.—Glenn R. Snider.

Problem.—To determine the comparative achievements of academically able eighth- and ninth-grade students in beginning algebra.

Procedure.—The study involved 66 eighth-grade and 62 ninth-grade students enrolled in beginning algebra in a junior high school in Muskogee, Okla. Within each grade, students were divided into two classes on the basis of IQ, arithmetic achievement, and the recommendation of their mathematics teacher.

Major Findings and Conclusions.—The eighth-grade students achieved significantly higher scores in algebra than did the ninth-grade students. There were no significant differences in gains in algebra achievement between the upper ability and lower ability groups.

94. **Laycock, Mary Chappell.** "Some Predictors of Success of Academically Talented Students in an Accelerated Mathematics Program" (M.S., 1961, University of Tennessee, Knoxville).

Major Faculty Adviser.—W. W. Wyatt.

Problem.—To determine the most valuable predictors of success in mathematics.

Procedure.—Information was gathered on 58 students in 2 accelerated mathematics classes in Oak Ridge High School, Oak Ridge, Tenn. Included were teacher rank of pupil's mathematical competence, College Qualification Tests, Kuder Occupational Test for 13 occupations that demand an understanding of mathematics, STEP Mathematics Tests Level 1, number of years of parents' education, and 11 subclusters of Siegel's Biographical Inventory. Means and standard deviations for each of the measures were computed by the ORACLE at the Oak Ridge National Laboratory. Three intercorrelation matrices were calculated by the Pearson product-moment formula.

Major Findings and Conclusions.—Teacher rank of the pupils' mathematical competence and the College Qualification Tests showed a significant relationship with achievement in mathematics.

95. **Leake, Lowell, Jr.** "The Status of Three Concepts of Probability in Children of Seventh, Eighth, and Ninth Grades" (Ph. D., 1962, University of Wisconsin, Madison).

Major Faculty Adviser.—Henry Van Engen.

Problem.—To investigate how much seventh-, eighth-, and ninth-grade students know about selected elementary concepts of probability before any formal instructional program in their school mathematics courses.

Procedure.—The concepts studied were the idea of a sample space, the probability of a simple event, and the probability of the union of two or more mutually exclusive events. A 30-item test was administered to each of 72 children classified within categories defined by all possible combinations of two schools, three grades, two sexes, and two levels of arithmetic achievement. Ten items of the test were devoted to each concept. The scores were analyzed via a repeated-measurements analysis of variance. Since each subject received a score for each concept, there were 216 basic scores in the design.

Major Findings and Conclusions.—(*a*) The students had considerable knowledge of the three concepts, but exhibited several misconceptions with problems testing these concepts. (*b*) There were significant differences in the mean scores on the three concepts, in the mean scores of the three grades, and in the mean scores of the two levels of achievement, and there was significant interaction between levels of achievement and concept—all at the 0.01 level. (*c*) The effect of mental age, as represented by level of achievement, was 7.2 times as large as the effect of chronological age, as measured by grade. Mental age was more important in determining a subject's score than chronological age. (*d*) The study showed that there is a foundation of knowledge on which to base instruction in probability for superior and average students at the junior high school level.

96. **Leonhardt, Earl Albert.** "An Analysis of Selected Factors Related to High and Low Achievement in Mathematics" (Ph. D., 1962, University of Nebraska, Lincoln).

Major Faculty Adviser.—J. Galen Saylor.

Problem.—To determine the relationship between selected educational factors and achievement in mathematics.

Procedure.—In Nebraska, 45 schools were randomly selected, 15 from each of 3 enrollment groups in grades 9–12: 75–99 students, 150–199 students, and 300–399 students. Only schools offering geometry in the 10th grade were considered. The Cooperative General Mathematics Test was administered to approximately 1,300 students in the 45 schools. Further study was made of the two highest and two lowest ranking schools in each enrollment group.

Major Findings and Conclusion.—The group of larger schools offered more mathematics classes and had the highest mean score on the test. In the higher ranking schools of each group, a greater percentage of the students had attended town rather than rural elementary schools. More often, the teachers in the high-ranking schools had more undergraduate and graduate preparation in mathematics and had had longer tenure in their positions.

97. **Lindstedt, Sidney Axel.** "Changes in Patterns of Thinking Produced by a Specific Problem-Solving Approach in Elementary Arithmetic" (Ph. D., 1962, University of Wisconsin, Madison).

Major Faculty Adviser.—Henry Van Engen.

Problem.—To determine the changes in patterns of thinking produced by the problem-solving program of "Seeing Through Arithmetic."

Procedure.—The experimental group consisted of 75 sixth-grade students who had been taking the "Seeing Through Arithmetic" program for nearly 3 years. The control group consisted of 75 sixth-grade students who had been in the traditional program. Teachers were matched for training, experience, and general competence. Students were matched by IQ scores, rating by teachers, and a standardized vocabulary test.

Tests administered to each group included the Iowa Tests of Basic Skills, SRA Achievement, Laycock's Test of Mental Abilities, and two forms of an arithmetic test designed by the investigator.

Major Findings and Conclusions.—The experimental group showed superiority in solving problems with imaginative settings and with unfamiliar word and number symbols.

The investigation indicated no statistically significant difference between the two groups in problem-solving competence when that competence was measured by a test that contained only the basic form of each problem type. There was a significant difference in computational skill in favor of the experimental group.

98. **Ling, Harold Leroy.** "A Discriminative Study of Mathematics For All" (M.S., 1962, Mankato State College, Mankato, Minn.).

Major Faculty Adviser.—Warren J. Thomsen.

Problem.—To determine how much mathematics should be taught so as to help pupils to live successful adult lives, to be proficient in basic operations, and to make good judgments.

Procedure.—The study reviews the evolution of the mathematics curriculum in the public school. Applications reflect problems from the business and work world.

Major Findings and Conclusions.—The mathematics curriculum must develop the student's facility in mathematical reasoning to assist him in adapting to the ever changing society.

99. Loman, M. Laverne. "An Experimental Evaluation of Two Curriculum Designs for Teaching First-Year Algebra in a Ninth-Grade Class" (Ph. D., 1961, University of Oklahoma, Norman).

Major Faculty Adviser.—William R. Fulton.

Problem.—To investigate the effectiveness of the UICSM algebra text, compared with the traditional text.

Procedure.—Two first-year algebra classes of ninth-grade students in the middle track of a three-track program were the subjects for the study. One class used the State-adopted text and the other used the UICSM text, which stresses the discovery method.

Pre- and post-test scores made by each group on the UICSM Test of Understanding Basic Mathematical Concepts, the STEP Mathematics Test, and the Cooperative Elementary Algebra Test were compared by the t-test and analysis of variance.

Major Findings and Conclusions.—A statistically significant difference in the understanding of basic mathematical concepts in favor of the UICSM group was obtained in the upper one-third intelligence level. No real difference existed between the two groups at either the middle or lower one-third level of intelligence.

No apparent difference was found in achievement of mathematical ability or of manipulative skill between the two groups at any level of intelligence.

100. Lopez, Conception Rodriguez de. "A Program for Training Teachers for the Puerto Rican Elementary Schools in the Teaching of Arithmetic" (Ed. D., 1961, Teachers College, Columbia University, New York).

Major Faculty Adviser.—Howard F. Fehr.

Problem.—To develop a program of education in content and method adequate for proper instruction of arithmetic in the elementary school grades 1–6.

Procedure.—The literature on preservice arithmetic education of elementary school teachers was surveyed. An overview was made of Puerto Rican teacher-education institutions, and an analysis was done of their elementary-education program in arithmetic according to admission, certification, and graduation requirements. Institutions were visited, their catalogs and syllabi of relevant courses were examined, and key persons in the preparation of prospective teachers of arithmetic were interviewed. Criteria were formulated for a desirable mathematics program for elementary teachers and a program based upon these criteria was proposed.

Major Findings and Conclusions.—All teacher-education institutions should require at least 2 years of high school mathematics for admission and should test the mathematical knowledge and skills of candidates before permitting them to enroll in mathematics teacher-education courses.

The minimum certification requirement for elementary school teachers should be a bachelor's degree with a six-semester-hour background course in mathematics. Textbooks written in Spanish were needed for the mathematics education courses.

101. **Lyle, Elizabeth D.** "A Study of the Background Preparation and Attitudes of Upper East Tennessee Elementary Teachers Regarding Modern Mathematics" (M.A., 1962, East Tennessee State College, Johnson City).

Major Faculty Adviser.—Lester C. Hartsell.

Problem.—To accumulate additional information about the mathematical preparation of elementary teachers as a basis for improvement of the teacher-education program.

Procedure.—A one-page questionnaire was sent to 1,140 teachers of grades 1–6 in 4 cities and 6 counties in upper East Tennessee. Information was requested on education, age, teaching experience, mathematics background, previous attitudes toward mathematics, and attitudes toward modern mathematics.

Major Findings and Conclusions.—Responses were received from 48.3 percent of the mailings. A majority of the teachers held no opinion on modern mathematics. Of those with opinions, 77 percent expressed favorable attitudes; favorable attitudes increased as education increased. The typical amount of college training in mathematics consisted of college arithmetic. No college mathematics had been taken by 23 percent of the teachers. In-service education in modern mathematics was desired by 70 percent of the respondents.

102. **Maletsky, Evan Merle.** "The Relative Merits of Several Methods of Teaching Probability in Elementary Statistics" (Ph. D., 1961, New York University, New York).

Problem.—To test the relative merits of three methods of teaching certain topics in elementary statistics.

Procedure.—Three probability units were prepared. The first one based probability upon the elementary theory of sets. The discussion of probability was preceded by material on the concept of sets and related notation. The second unit followed the traditional approach, basing the fundamental rules of probability on the operations of addition and multiplication. The third unit included only a brief intuitive introduction to probability. The three student groups on which the units were tried were essentially random samples of a total of 12 sections of a one-semester elementary statistics course for nonmathematics majors at Montclair State College (New Jersey). The teaching of all groups was done by the researcher.

Major Findings and Conclusions.—The modern and traditional approaches failed to produce statistically significant differences at the 5 percent level in problem-solving ability in probability. However, results were in favor of the modern approach using sets.

103. **Manheim, Jerome H.** "The Genesis and Early Development of Point Set Topology" (Ph. D., 1961, Teachers College, Columbia University, New York).

Major Faculty Adviser.—Myron F. Rosskopf.

Problem.—To examine those philosophical problems and mathematical researchers that were important in the evolution of point set topology.

Procedure.—The writings of Hausdorff, Newton, Leibnitz, D'Alembert, Euler, and others were examined.

Major Findings and Conclusions.—The codification of calculus by Newton and Leibniz was taken as the starting point of the investigation. The problem of the vibrating string attracted the interest of mathematicians in the mid-18th century and stimulated debate about the notion of function.

Efforts to establish uniqueness criteria led Cantor to consider different classificaton of infinite sets of points and to the development of point set theory. The final step in the movement toward a topological spare was made by Hausdorff. Much of the 20th-century research in topology has been motivated by concepts first given by Hausdorff.

104. **McCauley, Susan Rock.** "Effect of Two Organizational Plans on the Attainment of the Concept of Linear Measurement by Fifth- and Sixth-Grade Pupils" (M.A., 1962, State College of Iowa, Cedar Falls).

Major Faculty Adviser.—Irvin H. Brune.

Problem.—To determine whether the special mathematics teacher plan or the self-contained classroom teacher plan is more effective in presenting the concept of linear measurement.

Procedure.—The study population was composed of 212 fifth- and sixth-grade pupils in the Cedar Rapids, Iowa, public schools. The gains were based on scores in the pretest in the fall and the post test in the spring. Both tests contained 16 items relating to linear measurement taken from the STEP Mathematics Test, Form 4A.

Major Findings and Conclusions.—There was no difference between the control group and the experimental group in development of the concept of linear measurement.

105. **McPherson, Ann Wesley.** "An Experimental Study Concerned with a Diagonally Extended Arithmetic Program in an Average Second Grade in Contrast to Horizontal or Standard Approaches" (M.S., 1961, University of Tennessee, Knoxville).

Major Faculty Adviser.—A. M. Johnston.

Problem.—To determine if a diagonal extention of the mathematics curriculum would develop more interest and a broader understanding.

Procedure.—A survey of recent studies was made to identify the pattern of extensions to be used in the study. Teacher-made tests and interest inventories were developed. These and the California Arithmetic Achievement Tests were administered at the beginning and end of the experimental period. Three classes of second-grade students participated in the study.

Major Findings and Conclusions.—The class using the diagonal extension of the mathematics curriculum made greater gains in reasoning and computation than either of the other classes and also made greater scores on the interest inventory. It was found that many of the second-grade children were ready for third-grade material.

106. **Mikkelson, James Elliot.** "An Experimental Study of Selective Grouping and Acceleration in Junior High School Mathematics" (Ph. D., 1962, University of Minnesota, Minneapolis).

Major Faculty Adviser.—Willis E. Dugan.

Problem.—To determine the effect of ability grouping with and without adjustment of the curriculum for the differentiated groups.

Procedure.—The top 70 students of both the seventh and eighth grades were selected on the basis of scores on achievement and intelligence tests, and teacher recommendation. In each grade the 70 students were randomly divided into experimental and control groups. In each grade the 35 experimental students were distributed among half the classes of the grade in "heterogeneous" grouping. The factors of time, teachers, and material were controlled in comparisons made between experimental and control groups.

Major Findings and Conclusions.—(*a*) No differences resulted from grouping junior high school students of superior mathematical ability together without accompanying adjustments in procedure or curriculum. (*b*) When junior high school students of superior mathematical ability were grouped together and the curriculum accelerated, a considerable saving of time was accomplished with little or no loss in mathematical skill and comprehension. (c) There was some evidence, although not conclusive, that removal of the students with superior mathematical ability from the class might be beneficial for the less able students.

107. MILLER, JACK W. "An Experimental Comparison of Two Approaches to Teaching Multiplication of Fractions" (Ed. D., 1961, George Peabody College for Teachers, Nashville, Tenn.).

Major Faculty Adviser.—Raymon C. Norris.

Problem.—To compare the effectiveness of two approaches in teaching a unit on mulitplication of fractions in elementary school.

Procedure.—The study involved two sixth-grade classes that made comparable scores on achievement and ability tests. The duration of the experiment was 9 days (45 minutes daily), plus 2 days for pre- and post-tests.

The teacher of the experimental class used a flannel board and felt discs, and two automated practice devices. The flannel board and felt discs were used to show fractional operations; pupils worked at the chalkboard, engaged in discussion, or worked at their desks. The latter half of each class period was spent in computational practice on automated devices.

Major Findings and Conclusions.—The gains made by the experimental group, both as a whole and at each of the ability levels—low, average, and high—were significantly greater than those made by the control group.

108. MILLIGAN, MERLE WALLACE. "An Inquiry into the Selection of Subject Matter Content for College Freshman Mathematics" (Ed. D., 1961, Oklahoma State University, Stillwater).

Major Faculty Adviser.—James H. Zant.

Problem.—To develop a process for selective content for a modern course in freshman mathematics generally and to use it in drawing up one specific course at one specific college

Procedure.—Selecting content for a course involved choosing course objectives, establishing criteria for weighing subject matter content, devising a method of rating topics for conformity with the criteria, and fusing the objectives, criteria, and rating scheme into an operative, discriminating procedure.

Major Findings and Conclusions.—Textbooks in mathematics should be written with greater attention to cyclic psychological order as well as the cyclic logical order intrinsic to the subject matter itself. Factors tending to disconnect the content of mathematics from contemporary developments must be explicitly described if another occurrence of rigid traditionalism in mathematics instruction is to be avoided.

109. Moses, John L. "A Comparison of the Results of Achievement with Programed Learning and Traditional Classroom Techniques in First-Year Algebra at Spring Branch Junior High School, 1961–1962" (Ed. D., 1962, University of Houston, Houston, Tex.).

Major Faculty Adviser.—William J. Yost.

Problem.—To determine if the programed learning method is superior to the traditional method in first-year algebra.

Procedure.—Experimental and control groups were created. Common testing procedures were employed. Comparisons in achievement by total groups were made and also by subgroups of differing ability levels.

Major Findings and Conclusions.—In total mastery by students of a given body of materials in first-year algebra, no appreciable advantage was found for either method.

The high-ability students proceeded more rapidly, completed more materials, and achieved a higher level of mastery with the programed materials. No advantage for the programed materials was found for the slow student, with some grounds for assuming the method to be disadvantageous for the slow learner.

110. Nachtman, William Robert. "An Instrument of Measurement to Appraise the Quantitative Abilities of the Educable Mentally Retarded Child" (Ed. D., 1962, Colorado State College, Greeley).

Problem.—To construct and validate an instrument to appraise arithmetic achievement of the 9- to 12-year-old educable mentally retarded child.

Procedure.—A pool of 119 items was collected, evaluated by a panel of judges, and tried with a pilot group. Ninety-eight items were selected for the main study. The test was administered to 334 subjects, age 9 to 12 years, classified as educable mentally retarded, in 11 school systems in 6 different States.

Major Findings and Conclusions.—Seventy-eight items were included in the final scale. The individual method of testing arithmetic achievement of educable mentally retarded children is practical and makes it possible to test the child who cannot read or write.

111. Nafziger, Mary Katherine. "A Study of Selected Arithmetic Understandings of Undergraduate Students in the Elementary Teacher Preparation Programs at Goshen College" (Ph. D., 1961, Northwestern University, Evanston, Ill.).

Major Faculty Adviser.—George A. Beauchamp.

Problem.—To investigate selected arithmetic understandings of undergraduate students in the elementary teacher-preparation program at Goshen College.

Procedure.—Interviews with all of the 82 full-time elementary-education majors enrolled during the 1959–60 school year were tape-recorded. Questioning the students' understandings of 11 algorisms comprised the basic structure of the interview. An analysis of each student's understandings was made on five levels ranging from zero, if the subject could not solve the algorism, to four, if he saw beyond the computational rationale.

Major Findings and Conclusions.—The three best-understood algorisms were those relating to addition, subtraction, and multiplication of whole numbers involving substitution. The three least understood algorisms were those relating to multiplication of mixed decimals by decimals, division of decimals, and division of mixed numbers by common fractions.

The differences between the arithmetic understandings of students who expressed a liking for arithmetic and those who were neutral or who expressed a dislike for arithmetic were significant at the 0.01 levels.

112. **Nelson, Charles Warren.** "A Comparison of Three Programing Techniques for the Development of the Concept of Mathematical Induction with Eighth-Grade Students" (Ph. D., 1962, University of Maryland, College Park).

Major Faculty Adviser.—John R. Mayor.

Problem.—To compare the relative effectiveness of three programing techniques for the development of the concept of mathematical induction.

Procedure.—The three program variations were (*a*) constructed response, fixed sequence; (*b*) multiple choice, fixed sequence; and (*c*) multiple choice, variable sequence. The program sequence was pretested with a group of university elementary-education majors and with two different groups of eighth-grade students. Three eighth-grade mathematics classes were used in the experiment. Seven class periods were required: one for pretesting, four for administration of the program, one for the post test, and one 2 weeks later for the retention test.

Major Findings and Conclusions.—The three programing techniques were equally effective as measured by post-test achievement and by retention of learned responses after a 2-week time lapse.

113. **Nelson, Leonard Doyal.** "Relation of Textbook Difficulty to Mathematics Achievement in Junior High School" (Ph. D., 1962, University of Minnesota, Minneapolis).

Major Faculty Adviser.—Donovan A. Johnson.

Problem.—To determine the effects of varied textbook presentations on the mathematics achievement of high-ability junior high school students.

Procedure.—The investigation involved 285 seventh-grade students and 460 ninth-grade students in 14 Minnesota schools. Each of six schools provided two experimental classes, and eight schools each provided two experimental ninth-grade classes. Seventh-grade classes were selected from the top half, and ninth-grade classes from the top third.

Both experimental classes in each school received mathematics instruction from the same teacher. In the seventh grade one of the experimental classes in each school used the SMSG R text designed for college-capable seventh-grade students while the other class used the SMSG M text which covered the same topics but in which the presentation had been simplified so as to be more suitable for slower learners. Similarly in the ninth grade, one of the experimental classes used the R text while the other used the M text.

Major Findings and Conclusions.—The M texts tended to facilitate the learning of mathematics for all high-ability students in this experiment except for the very highest achievers among them.

114. **Neureiter, Paul Richard.** "What Arithmetic in Second Grade?" (1962, State University College, Geneseo, N.Y.).

Problem.—To determine if the processes of "carrying and borrowing" as related to place value can be grasped by second-grade students.

Procedure.—Four second-grade teachers in the campus school emphasized the discovery approach and the use of semiconcrete materials in teaching "carrying and borrowing," as related to place value, along with the addition and subtraction facts. Emphasis on structural concepts received priority over memorization. The average IQ was 110.4. The Stanford Achievement Test was used to measure the achievement gain.

Major Findings and Conclusions.—The group achieved significantly above the grade placement norms of the test.

115. **Newman, Richard Stanford.** "Materials for a Course in Pre-Algebra Mathematics" (M.S., 1962, University of Utah, Salt Lake City).

Major Faculty Adviser.—L. Edwin Hirschi.

Problem.—To prepare a student workbook and teacher's guide for a pre-algebra mathematics course.

Procedure.—A careful survey of the new mathematics programs was made. The student workbook was designed to use the discovery method and to develop a readiness for more advanced mathematics. The areas of content were discovery patterns, numeration systems, sets, and factors and primes.

Major Findings and Conclusions.—These materials were expected to be new and appealing to the students in a general mathematics program.

116. **Oldham, Wilbur Richard.** "A Longitudinal Study of Reading and Arithmetic Achievement of Euclid, Ohio, Pupils Through the Intermediate Grades" (Ph. D., 1963, Western Reserve University, Cleveland, Ohio).

Major Faculty Adviser.—David P. Harry, Jr.

Problem.—To make a longitudinal study of the reading and arithmetic achievement of 1 class of pupils from grades 3 through 6.

Procedure.—Included in the study were all the seventh-grade pupils entering a Euclid public school in September 1961, for whom complete information covering the third through the sixth grade was available. Data for 305 boys and 289 girls were included. Reading, language, and arithmetic scores, IQ scores, and various "handicaps" to a total of 90 variables were fed into an intercorrelation matrix in an IBM 7070 computer. Besides the usual grade placement norms, anticipated achievement grade placement norms were used to compare each pupil with that particular homogeneous group whose educational experience, chronological age, and mental abilities were most like his own.

Major Findings and Conclusions.—(*a*) Mean total reading scores were 1.1 to 1.6 grades above actual grade level by the grade placement norms and 0.4 to 0.6 grades above the anticipated achievement grade placement norms. The girls had about 20 percent more high achievers than the boys in their respective IQ levels. (*b*) Mean total arithmetic scores were 0.7 to 0.9 grades above actual grade level by the grade placement norms, matched the anticipated achievement norms at the fourth-grade level, and were 0.2 grades above that expected at the sixth-grade level. (*c*) A marked relationship existed between achievement test results and IQ values; analysis of the "handicaps" indicated that many of them do not seem associated with the lowest quarter of the achievement scale, but for some individuals the concomitant variables seemed to be real barriers to high achievement.

117. **Oldweiler, Harry E.** "Suggested Topics for the Modernization of the Grade Eight Mathematics Curriculum" (M.S., 1961, University of Kansas, Lawrence).

Major Faculty Adviser.—Gilbert Ulmer.

Problem.—To develop topics for a transition from the traditional to the modern approach to mathematics.

Procedure.—Four topics were developed: numeration systems, elementary set theory, geometry, and properties of numbers.

Major Findings and Conclusions.—With these topics teachers are able to supplement the traditional eighth-grade mathematics program.

118. **Paradise, Michael Emmanuel.** "A Followup Study of the Colorado State College Mathematics Graduates, 1950–59" (Ed. D., 1962, Colorado State College, Greeley).

Problem.—To identify the strength and weaknesses of the Colorado State College preparatory programs for mathematics majors.

Procedure.—A questionnaire survey was made of the 1950–59 graduates of the College who had majored in mathematics. Responses were obtained from 80 percent.

Major Findings and Conclusions.—Graduates who were educators were less critical of the college mathematics curriculum than those who were employed by industry or the Government. Most of the graduates agreed that the college's advanced programs in mathematics were in need of improvement.

119. **Petersen, Gladys L.** "A Survey of the Attitudes of Campus School Teachers in Wisconsin Toward Scheduled Primary Arithmetic" (M. Ed., 1961, University of Wisconsin at Milwaukee, Milwaukee, Wis.).

Major Faculty Adviser.—Anthony V. Ingrelli.

Problem.—To survey the attitudes of the supervising teachers of the primary grades in the State colleges, the University of Wisconsin at Milwaukee, and the county teachers' colleges in Wisconsin toward scheduled arithmetic in the primary grades and the amount of time spent in teaching primary arithmetic.

Procedure.—A questionnaire including closed and open-end questions was used to gather data.

Major Findings and Conclusions.—Teachers preferred 20- to 30-minute instructional periods, scheduled in the morning, and using a systematic, sequential arithmetic program.

120. **Peterson, Kay Russell.** "Prime Numbers and Some of Their Uses as Concept Builders in Basic Mathematics" (M.S., 1961, University of Utah, Salt Lake City).

Major Faculty Adviser.—L. Edwin Hirschi.

Problem.—To collect and simplify some of the information available about prime numbers.

Procedure.—Related literature was surveyed and the data used as the foundation for the study.

Major Findings and Conclusions.—The study presented a brief history of some of the men who have made contributions to the knowledge of the fundamental properties of prime numbers. Divisibility properties of primes were discussed, and were then used to help prove that any composite could be expressed as a product of primes, that factorization of a composite into primes was unique, and that the number of primes was infinite. Methods of generating primes, the distribution of primes, and related information were presented.

121. PHILLIPS, JOSEPHINE M. "The Role of an Editor in the Production of Arithmetic Textbooks" (Ed. D., 1962, Teachers College, Columbia University, New York).

Major Faculty Adviser.—Howard F. Fehr.

Problem.—To investigate the responsibilities, qualifications, and competencies of editors of arithmetic textbooks produced for nationwide use.

Procedure.—The information most pertinent to the study was furnished by 12 educational publishers that issue an arithmetic series in use in substantial numbers throughout the country. One or more representatives of each of these companies was interviewed by the investigator. Supplementing this primary source of information were a few bibliographical references and the personal experience of the investigator.

Major Findings and Conclusions.—Every editor needs a broad general education and a firm command of the English language. Most publishers require their arithmetic editors to have had specific training in mathematics and some teaching experience. Beyond these qualifications is an ill-defined "editorial aptitude," compounded of a great many personal characteristics. For the most part, editors are trained on the job.

As custodian of the publisher's investment in the arithmetic series, the editor is responsible for everything which contributes to producing books which meet an educational need at the time when that need is felt. As custodian of the authors' interests, the editor is responsible for the best possible program as it performs in the classroom.

122. PICTON, JOHN ODELL. "The Effect on Final Achievement in Solid Geometry of an Introductory Unit Based Upon Developing Visualization and Understanding Through the Use of Models" (Ed. D., 1962, Montana State College, Bozeman).

Major Faculty Adviser.—Milford Franks.

Problem.—To determine the effect upon final achievement of the use of models early in solid geometry.

Procedure.—A 10-day introductory unit on model construction was developed. Teachers of the experimental groups used the introductory unit; teachers of the control group did not. Pupils in both groups were tested at the beginning and end of the course.

Major Findings and Conclusions.—No statistically significant difference in achievement between the two methods was found.

123. PODBELSEK, ALLAN ROY. "A Comparison Between the Effectiveness of Two Types of Programed Instruction" (M.S., 1962, Illinois State Normal University, Normal).

Major Faculty Adviser.—T. E. Rine.

Problem.—To compare the teaching effectiveness of the linear method and the branch method of programed instruction.

Procedure.—The same topic was programed by the linear method and by the branch method. These programs were given to relatively equivalent groups. Learning within each group was measured by the use of the same test both as a pretest and post test.

Major Findings and Conclusions.—A significant amount of learning occurred in both groups, but the statistical evidence supported the conclusion that there was no significant difference in the amount of learning produced by the two methods.

124. **Price, C. Gary.** "The Development and Use of a Programed Supplement for Teaching an Introduction to the Algebra of Sets" (M. Ed., 1963, University of Texas, Austin).

Problem.—To develop and evaluate programed material as an aid to instruction in the algebra of sets.

Procedure.—A programed unit was produced and used with a group of high school seniors. Eleven different scores were obtained on general and mathematics aptitude, general and mathematics achievement, and program-based achievement as determined by a differential obtained from pre- and post-test scores. A multiple regression study was performed using these data.

Major Findings and Conclusions.—The programing technique was successful. More material could be covered in less time.

125. **Ray, John James.** "A Longitudinal Study of the Effects of Enriched and Accelerated Programs on Attitude Toward and Achievement in Eighth Grade Mathematics and Ninth Grade Algebra" (Ed. D., 1961, Indiana University, Bloomington).

Major Faculty Adviser.—Philip Peak.

Problem.—To seek evidence on a type of junior high school mathematics program that would stimulate interest in mathematics and that could be successfully handled by the students.

Procedure.—The subjects were students in the university school. In the first year of the study, four sections of eighth-grade mathematics were used: one section used an accelerated program with a full year's arithmetic in the first semester and a first semester of algebra in the second semester; another section used an enriched program with 4 days of classroom instruction and 1 day of reading, oral reports, committee work, and films; another used a second enriched program with 4 days of classroom instruction and 1 day of reading, written reports, projects, field trips, and guest speakers; and the fourth section was the control group. During the second year of the study, a followup was made of all those subjects who were still attending the university school. In addition, four eighth-grade mathematics sections were used, with each getting 4 days of classroom instruction per week and 1 day of enrichment activities.

Major Findings and Conclusions.—(1) Eighth-grade students were capable of handling first-semester ninth-grade algebra. (2) Accelerated students achieve more than regular students. (3) Students taking enrichment work that calls for oral or written reports feel that they have a better chance to express their ideas in mathematics.

126. **Reid, Thomas.** "A Comprehensive Guide for the Use of Vector Analysis in Various Fields of Science and Mathematics" (M.S., 1961, University of Toledo, Ohio).

Major Faculty Adviser.—Carroll Amos.

Problem.—To define the areas of high school instruction in science and mathematics in which vector analysis could be used.

Procedure.—The study presented a comprehensive view of the fundamentals of vector analysis, applications to mechanics of particles, applications to geometry and trigonometry, and to electricity.

Major Findings and Conclusions.—The investigator's 2-year tryout of the material was the basis for concluding that the guide was effective.

127. **Riedesel, C. Alan.** "Procedures for Improving Verbal Problem-Solving Ability in Arithmetic" (Ph. D., 1962, State University of Iowa, Iowa City).

Major Faculty Adviser.—Herbert F. Spitzer.

Problem.—To compare the effectiveness of specific verbal problem-solving procedures.

Procedure.—Eleven experimental and nine control classes, composed of sixth-grade pupils in three Iowa City schools, took part in the study. Thirty problem-solving lessons, each written at two levels of difficulty were prepared. Following each lesson was an optional problem ("How's Your P.Q.?") that was much more difficult than the others. The experimental classes worked three lessons a week and the control classes followed the problem-solving program of their textbooks.

Major Findings and Conclusions.—The difference in mean gains on tests favored the experimental group. On the tape-recorded test the gain was significant beyond the 0.1 percent level and on the Iowa Tests of Basic Skills, between the 5- and 10-percent level.

128. **Ross, Ramon Royal.** "A Case Study Description of Underachievers in Arithmetic" (Ed. D., 1962, University of Oregon, Eugene).

Major Faculty Adviser.—Walter R. Hill.

Problem.—To develop case descriptions of 20 sixth- and seventh-grade students of average intelligence who were 2 or more years below their mental grade level in arithmetic achievement, as measured by a standardized arithmetic test.

Procedure.—Each case study involved assessments of intelligence, general achievement, arithmetic performance, reading performance, personality, sociometric data, teacher responses, school history, physical characteristics, and home environment.

Major Findings and Conclusions.—(1) Arithmetic underachievement generally did not become apparent until the fourth grade. (2) Subjects tended to be from home environments that provided little intellectual stimulation. (3) Subjects were, characteristically, withdrawn and defeated in their attitude toward school. (4) Subjects were underachieving in school subjects other than arithmetic. (5) Arithmetic underachievement appeared to be related to multiple factors rather than any single factor.

129. **Roth, Donald Wayne.** "A Comparison of Three New Mathematics Programs" (M.S., 1962, Illinois State Normal University, Normal).

Major Faculty Adviser.—Douglas R. Bey.

Problem.—To compare and contrast the content and objectives of three new mathematics programs.

Procedure.—The ninth-grade mathematics programs of Ball State College, the School Mathematics Study Group, and the University of Illinois Committee on School Mathematics were the basis of the study. Content, postulates, vocabulary, teaching techniques, concepts from higher mathematics, applications, and objectives were compared.

Major Findings and Conclusions.—The programs were similar although the UICSM program made the greatest use of the discovery method. More need for applications was noted, especially in the SMSG program.

130. **Rudnick, Jesse A.** "A Study of the College Preparatory Mathematics Curriculum of Public Secondary Schools in Selected Cities of the United States in the Academic Years 1957–58 and 1960–61" (Ed. D., 1962, Temple University, Philadelphia).

Problem.—To determine the changes taking place in college-preparatory mathematics programs in selected U.S. public secondary schools.

Procedure.—Schools selected were in a geographic spread of cities with populations of 75,000 or more. A detailed study of each school's course offerings in mathematics was made.

Major Findings and Conclusions.—(1) Algebra, geometry, and trigonometry were still the foundation of the college-preparatory program. (2) The number of schools offering elementary algebra to eighth-grade students with superior academic ability increased from 13 to 30 percent in the 3-year period. (3) In many cities solid geometry had been combined with plane geometry. (4) Statistics, probability, analytic geometry, and calculus were being quite commonly offered as senior courses. (5) The percent of schools offering the Advanced Placement Program had grown from 2 to 6 percent in the 3-year period.

131. **Rushton, Edward W.** "A Study of Retention of Factual Knowledge of Mathematics by High School Students in Grades Nine Through Twelve" (Ph. D., 1962, George Peabody College for Teachers, Nashville, Tenn.).

Major Faculty Adviser.—Willard Goslin.

Problem.—To determine the effectiveness of programed instruction on pupil retention of factual knowledge of high school mathematics.

Procedure.—Programed materials for three courses—algebra I, plane geometry, and algebra II—were prepared by mathematicians under the direction of an experimental psychologist. They were field tested prior to being used in the experiment.

For each course a teacher was assigned three classes to teach, using the three methods of instruction: the conventional method, the programed learning method with teacher assistance, and the programed learning method without teacher assistance. Throughout the experiment none of the pupils using programed materials was allowed to do any homework, while the control group, taught in the conventional fashion, was given the usual homework assignments.

Complete test scores on 377 pupils were obtained.

Major Findings and Conclusions.—In algebra I, the mean score for end-of-year achievement under the no-help method was greater than that for the help method; that for the help method was greater than that for the conventional method. Only the difference in mean achievement scored between the no-help method and the conventional method was statistically significant.

In plane geometry there was no significant difference for end-of-year achievement under the three methods of instruction.

In algebra II the mean score for end-of-year achievement under the conventional method was significantly higher than either the mean score for the help method or the mean score for the no-help method. The mean score in achievement under the help method was not significantly different from the mean score under the no-help method.

The mean scores for retention in the fall testing were not significantly different under the three methods of instruction, nor in any of the three courses.

132. SANDLER, BARNEY. "A Comparison of an Integrated Course in College Physics and Mathematics of One Semester Duration With Separate Courses in the Two Subjects in a Two-Year Community College" (Ph. D., 1961, New York University, New York).

Problem.—To compare the effectiveness of an integrated course in physics and mathematics with that of separate courses in the two subjects.

Procedure.—A set of physics principles and a set of mathematical concepts and processes were obtained through examination of college physics texts and research papers, and from these a fused course of study was developed. Thirty-six male freshmen from a population of 110 freshmen were selected at random for each of 2 groups. The control group was taught physics and mathematics by the traditional method and the experimental group by the fused method.

Major Findings and Conclusions.—There was a significant difference at less than the 1 percent level of confidence in favor of the experimental group in knowledge of facts, terms, and principles of physics and in ability to solve mathematics and physics problems. There was no significant difference in knowledge of mathematical terms and concepts.

133. SCHAUMBERGER, NORMAN. "A Comparison of Two Methods of Teaching Certain Topics in Analytic Geometry" (Ed. D., 1962, Teachers College, Columbia University, New York).

Major Faculty Adviser.—Myron F. Rosskopf.

Problem.—To compare the effectiveness of the vector method and of the traditional coordinate approach in teaching selected topics in plane and solid analytic geometry.

Procedure.—Four groups of students studying analytic geometry were selected from 34 classes taught by 20 different instructors in 5 colleges in the metropolitan area. Instructional groups were taught as follows: Group A—plane analytic geometry by means of a vector approach; group B—plane analytic geometry by means of a nonvector approach; group C—solid analytic geometry by means of a vector approach; and group D—solid analytic geometry by means of a nonvector approach.

Two multiple-choice, objective-type examinations were designed: Examination I for plane analytic geometry and examination II for solid analytic geometry. The final treatment of the data covered 282 students who took examination I and 186 who took examination II. The basic hypotheses of the study were (*a*) that the method by which a student learns analytic geometry does not affect his score on the examination, and (*b*) that the method by which a student learns analytic geometry does not interact with the Scholastic Aptitude Test (SAT) level to which he belongs.

Major Findings and Conclusions.—Neither of the hypotheses could be rejected at the 5-percent level of significance.

Questions found difficult by the vector groups were somewhat similar to those found difficult by the nonvector groups. The results indicated that selected problems in solid analytic geometry might be handled more easily by means of vectors, whereas others lend themselves to a nonvector treatment.

134. **SCHULER, NEVIN DEILY.** "The Effect of the Administration of Two Federal Laws on Secondary Mathematics in Selected States" (Ed. D., 1962, Pennsylvania State University, University Park).

Problem.—To determine the impact of two Federal laws—the NSF (National Science Foundation) Summer Institute Program and the NDEA (National Defense Education Act)—on secondary mathematics in selected States.

Procedure.—Data were gathered from critical studies, a sampling of the modern mathematics skills of secondary-school pupils, and an analysis of Federal reports.

Major Findings and Conclusions.—(1) Within the past decade there have been fundamental changes in school mathematics in content, organization, and presentation. (2) Observable changes in teachers who attended NSF summer institutes are an improvement in preparation and professional activities; there is also improvement in their students' attitudes toward mathematics. (3) The NSF Summer Institute Program and the NDEA have resulted in an increased number of employees and an increased budget for mathematics education services in State departments of public instruction. Since World War II, Congress has exerted a strong and growing influence over the organization, administration, and supervision of a selected area of the secondary school curriculum.

135. **SHAPIRO, ESTHER WINKLER.** "Attitudes Toward Arithmetic Among Public School Children in the Intermediate Grades" (Ph. D., 1961, University of Denver, Boulder).

Problem.—To investigate the attitudes toward arithmetic shown by children in the intermediate grades and the relationship of these attitudes to overall achievement, arithmetic achievement, arithmetic marks, and IQ.

Procedure.—Thirty students, 15 boys and 15 girls, from each of grades four, five, and six were randomly selected from the total population of each of the intermediate grades. A semistructured interview consisting of 19 questions was used to establish each child's feelings toward arithmetic. A group of three judges rated each of the 90 interviews. Test data and teacher marks were obtained from the school records. An arithmetic test was administered by the examiner to each child.

Major Findings and Conclusions.—(1) No significant change in attitude from grades 4 through 6 was found for the total group or for boys alone. Among girls, significant differences were found indicating that fifth-grade girls disliked arithmetic more than either fourth- or sixth-grade girls. Boys and girls in the fifth grade were shown to be more influenced by peer attitudes than those in other grades. (2) Girls in all grades who liked arithmetic were found to seek help in solving arithmetic problems more than boys. Sixth-grade boys perferred to work independently if they liked arithmetic and sought help if they didn't like arithmetic. Girls tended to be more persevering than boys. (3) Mean scores between groups of sixth-grade children who liked arithmetic and groups who disliked it proved significant in all areas. Those who liked arithmetic had higher IQ scores, higher grade placement scores in the achievement tests, and averaged a higher mark in arithmetic for the first semester of the school year in which the study was undertaken.

136. SHERMAN, HOMER CHARLES. "A Comparison of Soviet and Commonly Used Iowa Elementary Arithmetic Texts" (Ph. D., 1961, State University of Iowa, Iowa City).

Major Faculty Advisers.—Robert E. Belding and Herbert F. Spitzer.

Problem.—To make a comparative study of elementary arithmetic texts commonly used in the Soviet Union and those commonly used in Iowa.

Procedure.—A questionnaire survey was made to determine the Iowa elementary curriculum, subject time allotments, and commonly used arithmetic text series. Translations were made of representative problems appearing in Soviet elementary arithmetic texts. Features of the curriculums and arithmetic textbooks from the Soviet and from Iowa elementary schools were compared.

Major Findings and Conclusions.—(1) The Iowa elementary student typically enters the first grade 1 year younger than his Soviet counterpart but spends 6 years in elementary school, in contrast to the 4 years spent there by the Soviet student. (2) The Iowa elementary student attends school 1 day less per week, yet has more minutes of instruction per week, than his Soviet counterpart. (3) Iowa uses no uniform elementary arithmetic text, whereas the Soviet Union prints and distributes an elementary arithmetic text. (4) Verbal problems in Soviet arithmetic texts are complex compared to those in Iowa arithmetic texts. (5) More attention is given to oral calculations and multistep problems and exercises in Soviet elementary texts. (6) Arithmetic problems reflect social, cultural, educational, and economic situations in the Iowa elementary arithmetic texts as well as in the Soviet ones.

137. SHINE, AILEEN ELIZABETH. "Relationship Between Arithmetic Achievement and Item Performance on the Revised Stanford-Binet Scale" (Ed. D., 1961, University of Colorado, Boulder).

Major Faculty Adviser.—Kenneth L. Husbands.

Problem.—To determine whether relationships could be established between successful item performance on the Revised Stanford-Binet Scale and arithmetic achievement.

Procedure.—The study was based on a stratified sample of 318 students who entered the Kansas City public schools as kindergarteners and who remained in continuous attendance over a 5-year period. A psychometrist administered a Revised Stanford-Binet Scale to each pupil during the kindergarten year. Arithmetic achievement was measured in the second half of the fourth grade by the Iowa Test of Basic Skills.

Major Findings and Conclusions.—(1) There was a definite positive relationship between passing any item on the Revised Stanford-Binet Scale from "Year IV-6" through "Year VIII" and achievement in arithmetic, with the exception of item 2, "Year IV-6," and item 2, "Year V." (2) All types of items with the exception of the copying test correlated highly with arithmetic achievement.

138. **Showers, Frederick Plansfield.** "A Descriptive Synopsis of Programed Instruction as an Aid to Education" (M.S., 1962, Hobart College, Geneva, New York).

Major Faculty Adviser.—R. L. [illegible]einert.

Problem.—To support the argument in favor of programed instruction as an aid to education.

Procedure.—The author uses "descriptive" research to convince the reader of the desirability of using programed instruction. The argument is supported by a review of the history, theory, implementation, and probable outcomes of its use. Opinions, data, and conclusions, both for and against, are quoted.

Major Findings and Conclusions.—Programed instruction may best be incorporated into the educational system as a research tool for the classroom teacher.

139. **Shryock, Alfred Jerry.** "A Study of Mathematics Background Courses, for Elementary School Teachers" (Ph. D., 1962, State University of Iowa, Iowa City).

Major Faculty Adviser.—Herbert F. Spitzer.

Problem.—To obtain data and information on topics for a mathematics course for prospective elementary teachers.

Procedure.—The investigation was conducted in three parts by: (1) an examination of the content of eight textbooks designed for use in mathematics courses for prospective elementary teachers, (2) a questionnaire survey soliciting from 104 experienced teachers their judgments on the importance of various mathematical topics, and (3) administration of a mathematics test to 185 undergraduate students in elementary education to determine which topics they understood.

Major Findings and Conclusions.—(1) There was greatest agreement among the textboks on the topics from arithmetic, number theory, and approximate computation, and least agreement on topics from algebra, statistics, elementary logic, and informal geometry. (2) Experienced teachers considered the topics from arithmetic, approximate computation, and informal geometry more important than those from algebra, number theory, statistics, and elementary logic. (3) The test data revealed that eight items from arithmetic, number theory, statistics, elementary logic, and informal geometry were not understood if an index of difficulty of less than 50 percent be arbitrarily chosen as a criterion for understanding. All items from algebra and approximate computation were understood if an index of difficulty of 50 percent or greater be chosen. There was no significant difference in mean score between the 69 prospective teachers who had taken no college mathematics courses and the 116 who had taken at least one college mathematics course.

140. **Shuff, Robert Vance.** "A Comparative Study of Achievement in Mathematics at the Seventh and Eighth Grade Levels Under Two Approaches, School Mathematics Study Group and Traditional" (Ph. D., 1962, University of Minnesota, Minneapolis).

Major Faculty Adviser.—O. E. Domian.

Problem.—To determine the relative effectiveness of SMSG and traditional text materials at the seventh- and eighth-grade levels.

Procedure.—The experiment was conducted in the junior high schools of Roseville, Minnesota, for one year. Students were randomly assigned to groups to which experimental treatments were randomly assigned. Students participating numbered 216 seventh-graders and 172 eighth-graders.

Major Findings and Conclusions.—(1) The tests used in measuring the outcomes showed the traditional materials to be more effective. (2) SMSG materials appeared to have some advantage at the lower ability level. (3) Although the difference was not statistically significant, boys showed superior achievement in mathematics. (4) Institute training appeared to give the teacher no advantage over other teachers who were well prepared.

141. **SIGURDSON, SOLBERG EINAR.** "The Development of the Idea of Unified Mathematics in the Secondary School Curriculum 1890–1930" (Ph. D., 1962, University of Wisconsin, Madison).

Major Faculty Adviser.—Edward A. Krug.

Problem.—To trace the idea of unified mathematics and to determine its place in the secondary school in the years 1890–1930.

Procedure.—The researcher develops an expository treatment of the topic.

Major Findings and Conclusions.—Parallel courses in algebra and geometry were followed by a correlation of mathematics and science. "General Mathematics" was conceived with the idea of a unified mathematics, but it developed into a kind of social mathematics and eventually became an alternative to algebra in the regular high school. Throughout the entire period there was never a clear definition of unified mathematics, and by 1930 the idea had faded from the educational scene.

142. **SKYPEK, DORA HELEN.** "A Comparison of the Mathematical Competencies of Education and Non-Education Majors Enrolled in a Liberal Arts College" (M.A., 1961, Emory University, Atlanta, Ga.).

Major Faculty Adviser.—Donald Ross Green.

Problem.—To explore the possibility that a deficiency in mathematical competence is a characteristic of liberal arts college students who, at the beginning of their junior year, select teacher education as a major.

Procedure.—Subjects were 282 junior and senior women enrolled in the College of Arts and Sciences, Emory University. The following competencies were investigated: (1) number of years of high school mathematics completed; (2) grade averages in high school mathematics; (3) Scholastic Aptitude Test—Mathematics scores; (4) scores on the college entrance mathematics examination; (5) grade-point averages in the required introductory mathematics course; (6) number having to repeat the introductory course; and (7) number completing electives in mathematics.

The Scholastic Aptitude Test—Verbal scores and overall grade-point averages were included as control variables.

Major Findings and Conclusions.—Teacher-education students were mathematically less competent than other members of the junior and senior classes. Although not generally different from other students in college-admissions requirements and in control variables, they were inferior in the college-related variables of mathematical competencies.

143. **Slusser, Theodore E.** "A Comparative Study in Division of Fractions in Which an Explanation of the Reciprocal Principle is the Experimental Factor" (Ed. D., 1962, University of Pittsburgh, Pa.).

Major Faculty Adviser.—Herbert T. Olander.

Problem.—To determine, for two methods of teaching the division of fractions—the common denominator and inversion methods—the relative effectiveness of including or omitting an explanation of the reciprocal principle as the rationale behind inversion.

Procedure.—Eleven classrooms and 299 sixth grade pupils were involved. Pupils in the control and experimental groups were equated within two points of IQ scores and within two points on scores on a review of fractions test.

Five control classes received all of their instruction from a basic arithmetic textbook. The six experimental classes received instruction from twelve lessons planned by the investigator in addition to instruction from the same basic textbook. The experiment covered 20 class periods of about 45 minutes each on successive days.

An analysis was made of the errors and methods of solution revealed by test papers and tape-recorded interviews.

Major Findings and Conclusions.—Instruction in division of fractions with an explanation of the reciprocal principle as the rationale behind the inversion method was less effective than instruction which simply taught the pupils to invert the divisor and multiply.

Faulty computation produced 34 percent of the errors in both control and experimental groups.

144. **Smith, Kenneth A.** "A Comparison of a Traditional and Several Modern First-Year Algebra Texts" (M.S., 1961, Oklahoma State University, Stillwater).

Major Faculty Adviser.—James H. Zant.

Problem.—To make a comparative study of one traditional, and three modern, first-year algebra texts.

Procedure.—A detailed analysis was made of the following texts, the first three of which were the modern ones: (1) Brumfiel, Eicholz, and Shanks, *Algebra I*; (2) School Mathematics Study Group, *Mathematics for High School—First Course in Algebra*; (3) *University of Illinois Committee on School Mathematics, First Course;* and (4) Mallory, Skeen, and Meserve, *First Course in Algebra.*

Major Findings and Conclusions.—The methods of attacking the principal ideas of algebra were quite different, but the three modern texts covered the same content. The Brumfiel, Eicholz, and Shanks text, which was well organized and had a definite purpose, would be rigorous for many classes. The SMSG text took a similar approach, but tended to present difficult concepts at a slower pace. The UICSM text, which used the discovery principle extensively, was the most untraditional of the three modern programs. The main criticism of the traditional text was that it lacked a coordinated attack on the central themes of algebra.

145. **Smith, M. Daniel.** "An Exploration of Non-Wordal Programing in Mathematics and Science" (1962, Earlham College, Richmond, Ind.).

Problem.—To develop programed materials and media for their presentation, and to observe their effects on the curriculum.

Procedures.—Small groups of students were used as tryout subjects in developing a non-wordal program of about 250 steps. Responses were conditioned to the concept of vectors. Adding directed numbers and dealing with coordinate numbers were included.

Major Findings and Conclusions.—The term "nonwordal" describes mathematical symbols, graphs, and similar textual stimuli. Nonwordal programing is that in which the most relevant properties of the stimulus are nonwordal. The inept use of words as well as the overuse confuses the student and conditions irrelevant behavior.

One of the advantages (sometimes a disadvantage) is that learning is less dependent on previous learning. A given random selection of students is more homogeneous with respect to it than to some "meaningful" explanation; this applies to students from varied populations—retardates, underprivileged, immigrants, adult illiterates, and other typical or special groups.

In general, the program has been successful, and it is thought that such nonwordal sequences are potentially effective for widespread use.

146. SMITH, NORMAN HANKELE. "The Teaching of Elementary Statistics by the Conventional Classroom Method of Instruction Versus Programed Instruction" (Ed. D., 1962, University of Colorado, Boulder).

Major Faculty Adviser.—Harold M. Anderson.

Problem.—To compare the conventional classroom method of instruction with programed instruction.

Procedure.—The experiment involved a short course in elementary statistics taught at the U.S. Air Force Academy in December 1961. A programed text used in the experiment was prepared by the experimenter.

Two sets of criterion data were collected: individual scores on a final test, and the time consumed by each subject in completing the course. Hypotheses on the significances of the difference in overall effect, the effect at different ability levels, and the variances of scores produced by the two treatments were assessed for each set of data. The final test was prepared by the experimenter. Its coefficient of reliability was computed using Cronbach's coefficient alpha, and was found to be 0.82 after being adjusted by the Spearman-Brown Formula.

A questionnaire was used at the end of the course to measure interest in statistics and attitude toward programed instruction.

Major Findings and Conclusions.—Analysis of the final test scores revealed no significant difference in overall achievement or achievement at different ability levels. A highly significant difference in overall time consumed in completing the course was obtained, but the results were inconclusive in regard to the various ability levels. The average time used by the group which received programed instruction was 66 percent of that used by the group which received conventional instruction. No significant difference between the variances of the two treatment groups was obtained for either set of data.

The questionnaire revealed a generally favorable student attitude toward programed instruction. Most of the subjects who studied from the programed text felt that programed instruction should supplement rather than replace conventional classroom instruction.

147. **Solomon, Nellie Ollivene.** "Factors Associated with Children's Attitudes toward Arithmetic" (M.S., 1962, University of Tennessee, Knoxville).

Major Faculty Adviser.—A. M. Johnston.

Problem.—To determine the relationship between children's attitudes toward arithemetic and their general ability to learn, teaching methods used, their parents' attitudes toward arithmetic, and their grade level.

Procedure.—One hundred students were selected from a population of 589, enrolled in grades 3 through 8. The availability of student cumulative records and the willingness of teachers to participate in the study were factors limiting the selection. Data were gathered through an attitude survey of the children and their parents, an arithmetic achievement test administered to the teachers, a forced-choice test for pupils' attitudes toward specific arithmetic processes, and a survey of teaching methods used in arithmetic instruction.

Major Findings and Conclusions.—The general ability to learn was found to be associated with the children's liking for arithmetic. The use of methods which failed to promote understanding of arithmetic concepts produced a dislike for arithmetic and the arithmetic teacher. Parents' attitudes toward arithmetic were closely related to their children's attitudes, but not to their achievement.

Chronological age, mental maturity, sex, and specific arithmetic processes were found to be unrelated to the children's attitude toward arithmetic.

148. **Sommerfield, Roy E.** *and* **Tracy, Neal H.** "A Study of Selected Predictors of Success in Second-Year Algebra in High School" (1961, University of North Carolina, Chapel Hill).

Problem.—To determine which of the instruments normally available would be effective in predicting success in second-year algebra.

Procedure.—The variables considered were School and College Aptitude Tests, the Lankton Algebra Achievement Test, and the algebra I grade. Simple and multiple correlations between and among the variables were made.

Major Findings and Conclusions.—Algebra I grademarks gave the highest correlation with Algebra II grademarks and showed the smallest standard error of estimate.

149. **Spross, Patricia McNitt.** "A Study of the Effect of a Tangible and Conceptualized Presentation of Arithmetic on Achievement in the Fifth and Sixth Grades" (Ed. D., 1962, Michigan State University, East Lansing).

Problem.—To study the comparative effects of two methods of presentation of arithmetic.

Procedure.—The subjects included 166 students in 8 heterogeneous classes in 2 elementary schools. There were two experimental and two control classes at fifth-grade and at sixth-grade level. The experimental classes were taught mathematical concepts, with tangible manipulative items used whenever possible. One concept was presented per week, with students producing some tangible item to represent their understanding of the mathematical idea of the week. Class periods were limited to 35 minutes per week; there was no ability grouping, no individual help, no homework, no drill, and no assignment of problems in any text. Once a week, students were given the opportunity to advance as far as possible in a series of graded problems. The control classes received the routine, self-contained classroom presentation of the structured program of the arithmetic text.

Major Findings and Conclusions.—Students in both the experimental and the control groups attained essentially the same progress in arithmetic and the same degree of understanding of mathematical concepts and their use.

150. **Stephen, Sister Marie, O.P.** "Research in History of Mathematics for Teachers" (1962, Edgewood College, Madison, Wis.).

Problem.—To investigate the claim that Albert the Great was a Dominican mathematician of the 13th century.

Procedure.—The investigation resulted from a study of the history of mathematics. The investigator conducted correspondence with historians of mathematics in search for data. A recently discovered manuscript *The First of Euclid with Commentary of Albert* has generated arguments pro and con.

Major Findings and Conclusions.—The author concludes that Albert the Great was a Dominican mathematician of the 13th century despite the lack of conclusive evidence. More studies in the history of mathematics are needed for teachers. As the program in the undergraduate division becomes more profound, it is necessary that historical and philosophical aspects keep pace.

151. **Stewart, Barba Mildred.** "How the Theory Underlying the Teaching of Fractions Has Changed Since 1900" (M.A., 1960, Ohio State University, Columbus).

Major Faculty Adviser.—Harold P. Fawcett.

Problem.—To study the various published viewpoints from 1900–62 on ways to teach fractions and fractional concepts to students of elementary mathematics.

Procedure.—Each decade was made the basis for a chapter, with the viewpoints and changes grouped into separate units. Changes in the theory were explicitly listed for consideration and comparison following the presentations of the viewpoints for the decades.

Major Findings and Conclusions.—The greatest changes in the theory of teaching fractions have occurred in the past 12 years. Great emphasis has been placed on making mathematical concepts understandable to the students. Some aids to understanding have been precision in language and clarity of definition. Stress has been placed on deriving and proving the rules that are used for performing operations with fractions.

152. **Stoll, Earline Lillian Hendryx.** "Geometric Concept Formation in Kindergarten Children" (Ph. D., 1962, Stanford University, Palo Alto, Calif.).

Problem.—To investigate (1) the relationship between the efficiency of learning simple concepts and the number of dimensions defined for the subjects and (2) the question of whether simple concepts are learned in an all-or-none fashion.

Procedure.—Eighty-eight kindergarten children were exposed to a series of 153 plane outline figures representing form concepts (polygons) or angle concepts. The subjects were randomly assigned to eight experimental conditions. Four groups learned the form problem and four learned the angle problem. The experimental variable was the number of model figures available at the time the stimulus was presented. There were four conditions for each problem: no-model, one-model, two-model, and three-model representations.

Major Findings and Conclusions.—(1) Support was given to the hypothesis that the rate at which these concepts are learned is related to the number of representative models present at the time the stimulus is presented, with the three-model groups learning the concepts most rapidly. (2) Thirteen of 15 tests supported the hypothesis that simple concepts of geometric form and angle size are learned in an all-or-none fashion. The Vincent curves supported the hypothesis of all-or-none learning for the quadrilateral, pentagon, and right angle.

153. STRAND, LYLE I. "The Teaching of Modern Mathematics on the Eighth-Grade Level" (M.S., 1962, Moorhead State College, Moorhead, Minn.).

Major Faculty Adviser.—Marion Smith.

Problem.—To study the effect of supplemental instruction in modern mathematics.

Procedure.—In addition to instruction in traditional mathematics, the experimental group of 26 eighth-grade students spent 15 minutes twice weekly for 6 weeks each on units on sets, number base, and comparison of addition in four different numeration systems. The control class of 17 eighth-grade students devoted all of their arithmetic time to traditional mathematics.

The t-test was computed on their seventh-grade marks, the Lorge-Thorndike IQ test scores, and on the Cooperative Mathematics Test for grades 7, 8, and 9. With the exception of the seventh-grade marks, there was no significant difference between these two groups at the 5-percent level of confidence at the beginning of the experiment.

Major Findings and Conclusions.—The experimental group made a significantly greater achievement gain. The significant difference may have been due to the sample, since the pupils were assigned to the groups on an alphabetical basis and did not have an equal chance of getting into either group.

154. SUDDUTH, MARTHA COOPER. "An Historical Survey of the Development of the Use of Instructional Materials for the Teaching of Arithmetic in the Elementary Grades as Recorded in Selected Publications" (Ed. D., 1962, Indiana University, Bloomington).

Major Faculty Adviser.—Ronald C. Welch.

Problem.—To survey the use of instructional materials in teaching elementary arithmetic in U.S. public schools, as recorded in selected publications.

Procedure.—Journals relevant to the field of education were studied, beginning with the first volume of each and ending with the volume published in June 1960.

Major Findings and Conclusions.—(*a*) The basic processes of addition, subtraction, multiplication, division, counting, measurement, and fractions were the teaching areas in which more than one-half of the materials were listed. (*b*) The materials were most often used to discover relationships, to stimulate or motivate the learner, to influence attitudes, and to develop understanding. (*c*) Pictures, supplementary references, games, and counting devices were most often used. (*d*) Their use showed a decided increase during the last two decades. (*e*) Almost twice as many materials were reported in *The Arithmetic Teacher* as in any other journal examined in the study.

(*f*) The attitudes of the writers were favorable toward the use of 86 percent of the material.

155. **Taylor, Mae Kiser.** "A Mathematical Program Incorporating the New Mathematics Principles and Processes into a Traditional Sixth-Grade Curriculum in Flatwood School of Jonesville, Virginia" (M.S., 1962, University of Tennessee, Knoxville).

Major Faculty Adviser.—A. Paul Wishart.

Problem.—To explore the degree to which sixth-grade students can learn concepts of new mathematics in addition to the principles and processes included in traditional mathematics.

Procedure.—An interest inventory, the Stanford Achievement Test, and a teacher-made test covering topics to be introduced during the study, were administered in September and again in May. Teacher-made tests were given before and after each topic.

Major Findings and Conclusions.—The class as a whole maintained the same degree of interest in mathematics while some individual students showed increased interest. As measured by the Stanford Achievement Test, a class growth of 2½ years was made.

156. **Tiemens, Robert Kent.** "The Comparative Effectiveness of Sound Motion Pictures and Printed Communications for the Motivation of High School Students in Mathematics" (Ph. D., 1962, State University of Iowa, Iowa City).

Major Faculty Adviser.—Samuel L. Becker.

Problem.—To test the effectiveness of sound motion pictures and printed communications as means for increasing the motivation of students.

Procedure.—First-year algebra classes with a total of 550 students from 17 Iowa high schools were randomly assigned to 3 treatment groups. Students in group I were shown three films illustrating practical applications of algebra in various occupations. Students in group II received comparable material presented in three printed booklets. Group III, the control group, received no experimental treatment.

Major Findings and Conclusions.—The film treatment resulted in superior achievement for the male subjects. The film group was superior to the control group on four of six criterion measures and to the print group on three of the criterion measures. No significant differences appeared between the print group and the control group.

157. **Tillotson, Donald Bearse.** "The Relationship of an Introductory Study of Calculus in High School to Achievement in a University Calculus Course" (Ph. D., 1962, University of Kansas, Lawrence).

Major Faculty Adviser.—Gilbert Ulmer.

Problem.—To determine the relationship of an introductory study of calculus in high school to achievement in a university calculus course.

Procedure.—Two groups in a first course in analytic geometry and calculus at the University of Kansas were identified: (1) those who had studied calculus in high school for less than a semester and (2) those who had studied no calculus in high school. Students were further classified into subgroups according to whether they were enrolled in the university course at (*a*) the most elementary level or (*b*) the intermediate or honors level.

From each cell of the 2 by 2 factorial design, 48 cases were selected. Two criteria of achievement were used: (1) the score on a common final examination and (2) the letter grade for the course.

Major Findings and Conclusions.—When adjustment was made for scholastic ability and general mathematics background, there was no evidence of significant difference in achievement in the university course between the two groups with and without high school calculus or between the two groups at different levels of instruction.

158. **Tolly, Harry R.** "A Follow-Up Study of the Mathematics Students Who Participated in the High School-University Credit Program in the Lincoln Public High Schools 1955–59" (M.A., 1962, University of Nebraska, Lincoln).

Major Faculty Adviser.—Milton W. Beckmann.

Problem.—To study the university progress of the mathematics students from Lincoln public high schools who participated in the High School-University of Nebraska Credit Program.

Procedure.—University and high school records were used as the source of information on the number of units earned in the credit program; the number of units earned in each of the three advanced courses in mathematics; the number of students in the program who enrolled in the University of Nebraska, in other colleges in Nebraska, and in out-of-State colleges; and the hours of college mathematics taken and the grademarks earned.

Students who matriculated at the University of Nebraska were polled by a questionnaire to determine the influence of the credit program on their college attendance and their attitudes toward the program.

Major Findings and Conclusions.—(1) Since its inception in 1954, the High School-University Credit Program has attracted more participants to its mathematics programs than to any of its other programs. (2) In the period 1955–59, 152 or about 65 percent of the students who took advanced credit examinations in mathematics became eligible to receive university credit. (3) Of these 152 students, 108 enrolled at the University of Nebraska. (4) About 30 percent of the students thought that participation in the advanced credit courses had given them additional encouragement to go on to college.

159. **Triplett, Le.** "An Investigation to Determine What Influence the Use of Differentiated Written Materials Has Upon Sixth Grade Students' Achievement and Understanding in Multiplication of Fractions When Compared With the Single Textbook Approach" (Ed. D., 1962, Colorado State College, Greeley).

Problem.—To determine if there was any significant difference in achievement in the multiplication of fractions by sixth-grade students when taught from a single textbook, or from differentiated written materials designed for three levels of performance in arithmetic.

Procedure.—Two sixth-grade classes, one control and one experimental, were randomly chosen. The Iowa Tests of Basic Skills were administered to determine the top 27 percent, the middle 46 percent, and the bottom 27 percent in each group. The study was conducted during a 6-week period using the experimental and control procedures.

Major Findings and Conclusions.—Significant differences in mean scores favored the experimental groups in computation problem solving, understanding, and total scores in the middle 46-percent group and in the bottom 27 percent.

160. TURNER, MARGUERITE ELIZABETH. "Construction, Validation, and Use of a Test for Measuring the Concept of Shape in Grades One Through Nine" (Ph. D., 1961, University of Connecticut, Storrs).

Major Faculty Adviser.—J. R. Gerberich.

Problem.—To evaluate students' concept of shape through a nonverbal, objective, group test for grades 1–9.

Procedure.—The first part of the study was concerned with development of a test to evaluate students' concept of shape. One hundred multiple-choice items were constructed, each containing four plane geometric figures, three of like shape and one of different shape. The problem for the subjects was to select the one of different shape. The second part of the study was an analysis of performance on the test.

Major Findings and Conclusions.—(1) There is a significant positive relationship between chronological age and understanding of the concept of shape. (2) There is a significant positive relationship between mental ability and understanding of the concept of shape. (3) There is not a significant relationship between sex and understanding of the concept of shape.

161. UMOSKI, THERESA J. "Teaching Machines and Programed Instruction in Mathematics" (M. Ed., 1962, Montclair State College, Upper Montclair, N. J.).

Problem.—To compile a concise handbook of available mathematics programs, together with the publishers and levels of instruction.

Procedure.—Essential information was obtained from manufacturers of teaching machines and from publishers of programed material. Distributors were classified according to the format in which the programs were most commonly published. Individual programs were classified according to subject matter.

Major Findings and Conclusions.—The directory of manufacturers of teaching machines and/or programed instruction consisted of 54 names and addresses, 53 of which were engaged in producing some form of programed instruction for mathematics. There were 95 mathematics programs available.

162. UPTON, FRANCES CAROLINE. "An Experimental Study of Teaching Aids at the First Grade Level" (M.A., 1962, University of California, Los Angeles).

Major Faculty Adviser.—Wilbur Dutton.

Problem.—To find out whether first-grade children learn place value better by the "bundles" method or the "hundred boards" method.

Procedure.—Four first-grade classes with a total of 103 children from differing socioeconomic backgrounds took part in the study. The IQ range was from 85 to 159. Fourteen lessons, each 20 minutes in length, were used. Two teachers started with the "bundles" method and after seven lessons changed to the "hundred boards" method. The other two teachers used the two methods in reverse order. Uniform procedures were prepared for presenting each lesson, and tests were devised to measure pupil understanding of place value.

Major Findings and Conclusions.—The hypothesis that children entering the first grade are able to comprehend place value was accepted. The concentrated, continuous work on place value produced mastery for most pupils.

The second hypothesis, that there is no significant difference in children's understanding of place value when taught by the "bundles" method or by the "hundred boards" method, was accepted. The "bundles" method showed slightly greater gains during the first part of the experiment but these disappeared as the study progressed. The two methods appeared to supplement each other.

163. **Valsame, James.** "A Study of Selected Aspects of Mathematics Teacher Training in North Carolina as Related to Recent Trends in Mathematics Teaching" (Ed. D., 1961, University of North Carolina, Chapel Hill).

Major Faculty Adviser.—Neal H. Tracy.

Problem.—To investigate the qualifications of mathematics teachers in the white public secondary schools of North Carolina for teaching modern mathematics.

Procedure.—Past and recent developments in secondary mathematics, including reports and recommendations of national groups, were studied to establish the national pattern. A survey of a stratified sample of all white secondary school teachers teaching two or more mathematics classes in public schools of North Carolina was made to determine the qualifications of these teachers and to provide other status information.

Major Findings and Conclusions.—(1) Many teachers of mathematics have very limited mathematics backgrounds. (2) Fewer than one-third of the respondents reported provision of mathematics inservice education by their school systems. (3) The typical respondent had not attended a summer session since 1950. (4) The work of only one of the four more influential national groups affecting secondary mathematics teaching was known by as many as one-half of all respondents. (5) Less than 40 percent of all respondents belonged to the National Council of Teachers of Mathematics.

164. **Walton, Susan Hansen.** "Mathematical Enrichment for Junior High School Mathematics" (M.S., 1961, University of Utah, Salt Lake City).

Major Faculty Adviser.—L. Edwin Hirschi.

Problem.—To develop a course of study for use as supplementary material for average or above-average students in the seventh or eighth grade.

Procedure.—Based on a review of the literature in the field, a course with the following topics was developed: sets and sentences, sets of ordered pairs, graphing, basic mathematical principles, frame equalities, numbers and numerals, number lines, comparing numbers, solution sets, subsets, intersections, and unions. A teacher's commentary was also included.

Major Findings and Conclusions.—The material was used with some degree of success with a summer school class of mathematically talented students who had completed the sixth grade.

165. **Ware, James Gareth.** "An Enrichment Program for Superior Students in High School Plane Geometry" (Ph. D., 1962, George Peabody College for Teachers, Nashville, Tenn.).

Major Faculty Adviser.—F. Lynwood Wren.

Problem.—To develop and evaluate a 15-week enrichment program for superior students in plane geometry.

Procedure.—Six brief units, comprising only 15 lessons altogether, were developed on content not usually offered in high school geometry: intuition, rubber-sheet geometry, logic, coordinate geometry, finite geometry, and non-Euclidean geometry.

Superior students were selected from nine geometry classes in six high schools. The six schools were paired according to type and size, and then one from each pair was randomly assigned as an experimental school and the other as the control school. Superior students in two of the schools had already been homogeneously grouped and these classes participated in their entirety.

The homogeneous experimental groups completed the enrichment units over the weekends. Superior students in heterogeneous classes were excused from class one day each week to work on the units. Students in the control groups carried on normal classroom activities.

Major Findings and Conclusions.—There was no assurance that the enrichment materials contributed to an increase in functional competence for either group. The homogeneous experimental group scored significantly higher on the Shaycoft Plane Geometry Test than the corresponding control group. There were indications that the enrichment material provided sufficient motivation for its study and that it contributed to greater student interest in mathematics. The technique offers one way of providing for individual differences.

166. WEINER, MELVIN. "A Comparison of the Effect of Two Teaching Techniques in Developing the Functional Competence of College Students in a First Semester Course in Mathematics" (Ph. D., 1961, New York University, New York).

Problem.—To determine the comparative effect of two methods of teaching mathematics on the functional competence of college students in a first-semester course in mathematics.

Procedure.—The control method consisted of starting with an explanation of the general concepts and then illustrating and applying these concepts to various exercises. The experimental method led up to the concepts through the use of a problematic situation.

Major Findings and Conclusions.—The experimental method produced significantly better results than the control method with average and below-average students. There was no significant difference in the results of the above-average students. With the group taken as a whole, the experimental method produced a signficantly better result than the control method.

167. WELKER, LATNEY CONRAD, JR. "A Study of Interrelationships in Arithmetical Problem Solving" (Ed. D., 1962, University of Southern Mississippi, Hattiesburg).

Problem.—To investigate interrelationships among the abilities to solve numerical verbal problems in arithmetic, to select procedures for solving them, and to do the needed computations.

Procedure.—Three tests were developed: (*a*) numerical verbal problems, (*b*) computation problems, and (*c*) nonnumerical verbal problems. The same basic problem situations were used in (*a*) and (*c*), the same computations in (*a*) and (*b*). The subjects were 831 students in grades 7–9.

Major Findings and Conclusions.—(1) The ability to solve nonnumerical problems by selecting the proper procedures was not as great as the ability to solve numerical problems involving the same basic problem situations. (2) The ability to solve numerical problems was not as great as the ability to perform calculations when told what procedures to follow. (3) The degree of success in solving numerical problems was more closely associated with the degree of success in solving nonnumerical problems than with that in accurate computations. (4) Academic aptitude was a positive factor in nonnumerical problem solving, numerical problem solving, and computation.

168. WHITAKER, MACK L. "A Study of Participants in Summer Mathematics Institutes Sponsored by the National Science Foundation" (Ed. D., 1961, Florida State University, Tallahassee).

Major Faculty Adviser.—Eugene D. Nichols.

Problem.—To gather selected items of information on secondary school mathematics teachers who participated in summer institutes sponsored by the National Science Foundation.

Procedure.—A questionnaire was mailed to a randomly selected sample of 466 participants residing in the United States. Information was requested about the participant's (1) professional training and experience, (2) change in curriculum emphasis after attending an institute, (3) change in professional assignment and responsibilities, and (4) judgment on selected topics offered in institutes.

Major Findings and Conclusions.—Based on a return of 70 percent, the following findings were reported: More than 50 percent of the respondents held a master's degree and more than 40 percent had taken 30 or more semester hours of college mathematics. Almost three-fourths of the respondents had introduced or expanded their treatment of the elements of set theory and numeration systems on bases other than 10. Topics of matrix algebra and analytical trigonometry were taught by fewer than 20 percent. About 45 percent of respondents were using an experimental type of textbook in their teaching, and more than 50 percent of these were using publications of the School Mathematics Study Group. Among eight selected topics frequently taught in summer institutes, participants rated "trends and developments in secondary mathematics" as most valuable and "probability and statistics" as least valuable. The ratings of "basic concepts of geometry" and "theory of numbers" differed significantly when groupings were constructed on the basis of number of years of teaching at least one course in mathematics and number of institutes attended, respectively.

169. WHITMAN, NANCY CHONG. "The Development of a Test of Conceptual Knowledge Basic to the Teaching of Arithmetic" (Ph. D., 1961, University of Illinois, Urbana).

Problem.—To construct a test of conceptual knowledge of arithmetic.

Procedure.—The items chosen for inclusion in the test were those which (1) asked for knowledge which could help an elementary school teacher to answer and explain a possible "why" question, (2) pertained to topics that are commonly mentioned and are considered basic to teaching arithmetic, and (3) satisfied certain statistical requirements.

Major Findings and Conclusions.—Using Guttman's formula and an even-odd split-half method of obtaining a measure of reliability, an estimated coefficient of reliability of 0.85 was obtained, N being 570. By the same procedure an actual coefficient of 0.69 was obtained, N being 78. The estimated reliabilities of the three subgroups of the 570 sample were: 0.79 for National Science Foundation students at a Mathematics Year Institute, 0.68 for students with a content course in arithmetic at the college level, and 0.64 for students without such a content course.

170. **Wiersma, William, Jr.** "A Study of National Science Foundation Institutes: Mathematics Teacher's Reactions to Institute Programs and Effects of These Programs on High School Mathematics Courses" (Ph. D., 1962, University of Wisconsin, Madison).

Major Faculty Adviser.—Henry Van Engen.

Problem.—To determine the effects of National Science Foundation (NSF) Summer Institutes (SI) in Mathematics upon high school mathematics programs in the 11 largest cities in Wisconsin.

Procedure.—A questionnaire was sent to the mathematics teachers of the 11 cities who had attended an SI in mathematics. A 93-percent return was received. Another questionnaire on reasons for not applying for NSF institutes was sent to the remaining mathematics teachers of the same cities. A 94-percent return was received.

Major Findings and Conclusions.—(1) Institute attendance did increase the participants' understanding and knowledge of mathematics and their confidence in presenting the subject. Participants were generally well satisfied, program and quality of instruction were rated high, and the mathematics courses were generally not considered too difficult. There was some dissatisfaction with the administrative aspects. The major type of curriculum effect was the introduction of new ideas and their integration into the traditional course. There was little indication that modern mathematics courses had been set up by the participants, and there were strong indications that administrative policies were the primary factors inhibiting curriculum change.

Male nonparticipants did not apply for institutes because the remuneration was too small. Female nonparticipants had varied reasons, but for married females the most frequently given reason was "family responsibilities."

171. **Wilkins, Letha Dalton.** "An Experiment Concerned with the Classroom Teacher's Part in the Teaching of Third-Grade Arithmetic by Television" (M.S., 1962, University of Tennessee, Knoxville).

Major Faculty Adviser.—Alberta L. Lowe.

Problem.—To study the effect of an instructional television program on the learning of arithmetic by third-grade students.

Procedure.—Two third-grade groups viewed a television program twice a week for 12 weeks. For 6 weeks one class had an introduction and followup to the telecast and the other merely viewed the program. Then the two classes used the reverse procedures for 6 weeks. Teacher-prepared tests were given before and after the experiment. The tests were compared for gains in arithmetic, spelling, and reading.

Major Findings and Conclusions.—The analysis of data for the first half of the experiment revealed a significant difference in favor of the class receiving teacher help but no difference for the second half of the experiment. Both classes showed a greater gain in arithmetic than in reading or spelling.

172. **Willcox, Alfred Burton.** "The Amherst Freshman Program in Mathematics and Physics" (1962, Amherst College, Amherst, Mass.).

Problem.—To present experimental evidence in support of a required course combining mathematics and physical science.

Procedure.—A description of the course called "Science 1, 2," which is administered and taught jointly by the departments of mathematics and physics. It presents an introduction to the physical sciences and to the calculus that explores and exploits the historical connections between the two subjects in a way that does not obscure the essential independence of mathematics from any particular model. The mathematics content is essentially that of a first course in analytic geometry and calculus, shortened to fit into 4 semester hours.

Major Findings and Conclusions.—Advantages are that the physics problems serve as motivation for definitions or as applications of results. Mathematical concepts and physical applications occur naturally in close proximity and tend to reinforce each other.

A disadvantage is that a mathematics major, at the end of his sophomore year, is somewhat behind his contemporaries at some sister institutions, and thus an extra burden is placed on the upperclass curriculum to provide adequate preparation for graduate school.

173. **Williams, Emmet D.** "Comparative Study of SMSG and Traditional Mathematics" (Ph. D., 1962, University of Minnesota, Minneapolis).

Major Faculty Adviser.—Otto Domain.

Problem.—To compare the mathematics achievement of students taught with SMSG materials with that of students taught with traditional mathematics texts.

Procedure.—Students from the ninth grade in two junior high schools were selected. Also, 10th-grade students electing intermediate algebra were randomly assigned to eight classes. After instruction, one group of students with previous SMSG training and another with the traditional mathematics background were selected for comparison, both groups being composed of high-intelligence students.

The Verbal Reasoning and Numerical Aptitude tests of the DAT battery were used to measure intelligence with pre- and post-tests of the STEP mathematics and Cooperative algebra to measure mathematics achievement.

Major Findings and Conclusions.—No significant differences in achievement between student groups using the SMSG materials and those using the traditional materials were found.

174. **Williams, Horace Edward.** "A Study of the Effectiveness of Classroom Teaching Techniques Following a Closed-Circuit Television Presentation in Mathematics" (Ph. D., 1962, George Peabody College for Teachers, Nashville, Tenn.).

Major Faculty Adviser.—John H. Banks.

Problem.—To compare three methods of classroom followup after a 25-minute closed-circuit television presentation in mathematics.

Procedure.—The population for the study were the college students, primarily freshmen and sophomores, enrolled in a general education course in principles of college mathematics. The three methods used were as follows: (1) the television lecturer conducted the followup session on television by answering questions relayed to the studio; (2) the classroom instructor used the followup period to answer pertinent questions; and (3) the instructor used the followup session to lecture on supplementary ideas.

A unit of material extending through three weeks of instruction was selected for the study. Ability measures were collected. At the end of the three-week period, the students were administered a multiple-choice test with a reliability estimate of 0.82. Four weeks later, another form of the achievement test was administered. Analyses of covariance at the 0.95 level of confidence were used in analyzing the results.

Major Findings and Conclusions.—(1) No significant differences in achievement were found among the three methods. (2) No significant interactions were found between the methods and ability levels of the students for the population sampled.

175. WILLOUGHBY, STEPHEN S. "Representations by Means of Formal Mathematical Structures" (Ed. D., 1961, Teachers College, Columbia University, New York).

Major Faculty Adviser.—Myron F. Rosskopf.

Problem.—To examine the formulation of mathematical models for several branches of the social sciences.

Procedure.—Four models were studied that illustrate two basic, often conflicting, requirements in model-making: that the model be a reasonably accurate description of the real world and that it lend itself to mathematical analysis.

Major Findings and Conclusions.—There are many reasons for making mathematical models. They can be used to predict future events, to describe desirable behavior, to organize large masses of data and help direct gathering of more useful data, and to indicate common elements among apparently different problems.

Perhaps the most important use of models in the social sciences is to remove ambiguity. Since investigation of mathematical models in the social sciences is a young and rapidly expanding area of thought, students now in the schools and colleges will probably contribute greatly to its further development. To speed that development it seems desirable for teachers and pupils to become aware now of some of the problems and possibilities in creating new mathematical models.

176. WINSOR, DONALD LIVINGSTON. "The Development of a Course for Inservice Education Through Television" (Ed. D., 1961, University of Florida, Gainesville).

Problem.—To investigate the use of educational television in offering a course to inservice elementary school teachers on teaching arithmetic.

Procedure.—The course, The Teaching of Arithmetic, was offered for credit to 33 teachers in the Jacksonville, Fla. viewing area. Sixteen half-hour telecasts, seven 2½-hour seminars, and individual instruction were used to present the course.

Major Findings and Conclusions.—The television class gained in understandings of arithmetic concepts to the same degree as did the control classes, who were taught in the conventional manner.

177. **Wojtusik, Edward P.** "A Comparative Study of the Effect of the Number of Class Meetings on the Mathematical Achievement of Two Algebra II Classes" (M.S., 1961, Central Connecticut State College, New Britain).

Major Faculty Adviser.—George Spooner.

Problem.—To determine whether increased class time would result in increased achievement in algebra.

Procedure.—Two groups of students were included in the study. One group met four times a week for the year, and the other, five times a week. Identical materials were covered in each class. At the end of the year, both groups were given the Cooperative Intermediate Algebra Test.

Major Findings and Conclusions.—The group that met five times a week achieved more in algebra II than the other group.

178. **Wong, Ruth Hie-King.** "A Study of Student Progress Through Grouping Associated with a Program of Sequenced Instruction in Elementary School Mathematics" (Ed. D., 1962, Harvard University, Cambridge, Mass.).

Major Faculty Adviser.—David V. Tiedeman.

Problem.—To compare student progress in arithmetic achievement through teacher instruction vs. self-instruction in a nongraded elementary school.

Procedure.—The exploratory phase of the study revealed that oral instruction could not be provided in sufficient quantity to match the spread in arithmetic achievement. Self-instructional units were written to parallel those presented orally by the teacher.

A total of 65 students in two groups were compared in order to examine the relative achievement produced by teacher instruction and by self-instructional materials. For neither group was any ceiling on effort imposed. The three teachers in charge of oral instruction regrouped their children among them as the spread dictated; through the sequenced nature of the material, those children under self-instruction were automatically regrouped each day. The same unit tests were administered to pupils of both groups.

Major Findings and Conclusions.—For the group as a whole, the results were statistically significant in favor of self-instruction; however, examination of subgroup behavior revealed that the high-ability groups were not significantly different in their performance in the first period, and that the slow groups were not significantly different for either period.

179. **Woods, Dale.** "Topical Content for Certain Fifth-Year Mathematics Courses for Missouri Secondary School Mathematics Teachers" (Ed. D., 1961, Oklahoma State University, Stillwater).

Major Faculty Adviser.—O. H. Hamilton.

Problem.—To determine the topics from algebra, probability and statistics, and geometry to be included in a fifth year of study for Missouri secondary school mathematics teachers.

Procedure.—A set of criteria for use in selecting content was established and validated from the responses of a panel of mathematics educators. Topical selections were determined by analysis of the responses to a mail questionnaire of directors of National Science Foundation 1961 Summer Institutes.

Major Findings and Conclusions.—Panelists agreed on the nucleus of topics to be included, but responses indicated a need for further study of the geometry to be covered.

180. **Worth, Georgie Nell.** "The Development and Evaluation of a Creative Mathematics Program in a Fourth Grade" (M.S., 1962, University of Tennessee, Knoxville).

Major Faculty Adviser.—A. M. Johnston.

Problem.—To develop and evaluate a program of creative mathematics in a fourth grade.

Procedure.—The investigator developed an experimental mathematics program that was designed to stimulate greater interest, a more favorable attitude toward mathematics, and creative activity by the students. Teacher-made inventories and standardized tests were administered.

Major Findings and Conclusions.—Greater interest and more favorable attitudes were stimulated. The average gain of individual progress was more than a year, with a median gain of 1.9 years. Much creative student activity was evidenced.

181. **Yasin, Said Taha.** "The Reform Movement in Secondary Mathematics: Its History and Present State" (Ph. D., 1961, Indiana University, Bloomington).

Problem.—To describe the reform movement in secondary mathematics.

Procedure.—The study is an historical survey of the reform movement in mathematics education beginning about 1890.

Major Findings and Conclusions.—The reform movement began in Europe towards the close of the 19th century and then spread to the United States. The reform started with efforts to correlate mathematics with science and other fields of knowledge. Following the economic depression, the great increase in numbers of students in secondary schools and the inability of many to achieve satisfactorily in mathematics led to a decreased emphasis in mathematics. After World War II, competition with the Soviet Union has resulted in greater attention to mathematics and especially as relevant to technological developments.

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